



Get more motor out of your motor.

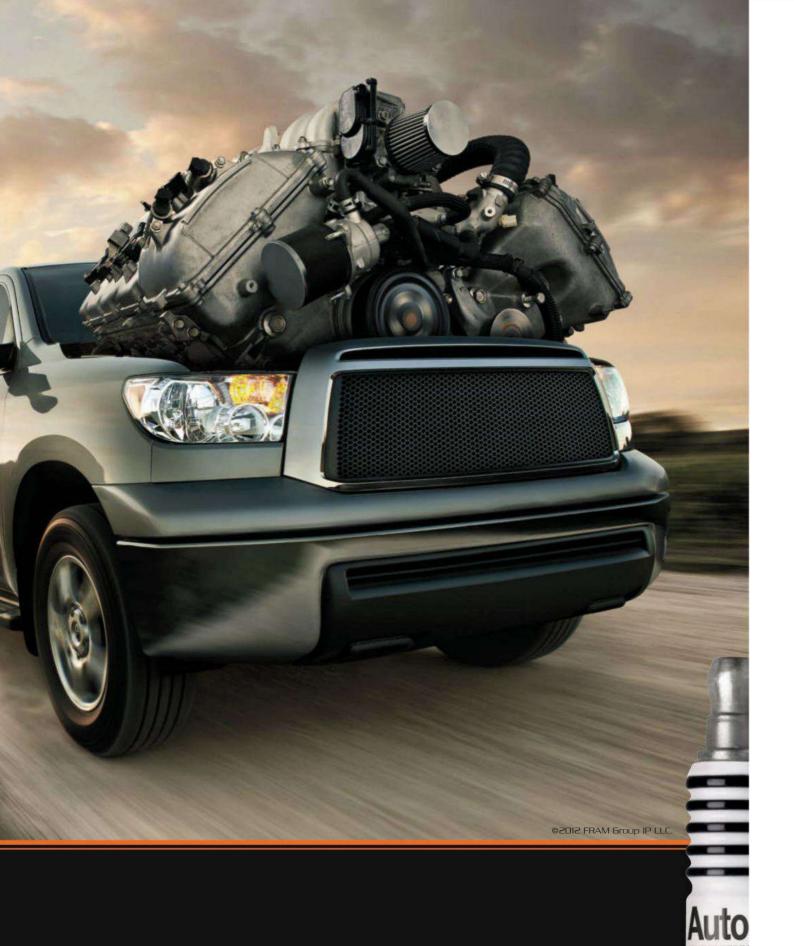
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IGNITION

Writer Sam Smith gives the 2012 Ford Mustang Boss 302's V-8 a break outside a motel in North Platte, Neb. 92

PHOTOGRAPH BY THOMAS PRIOR

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UPGRADE Gear, Tools, Gadgets25

AUTO INTEL Test Drives, Car Tech,

Hot Rides 36

COLUMNS

I'll Try Anything: Swamp Buggying54 **FEATURES**

Looking Downrange PM trains with U.S. Special Ops forces as they prepare for the drawdown in Afghanistan-and missions beyond.

So You Want to Buy an **Ultrabook** It's light, powerful—and might well be your next PC.

Welcome to the New Solar **Maximum** As our dependence on technology grows, so does the threat of solar storms.

BY LEE BILLINGS86 Freedom of the Road Driving crosscountry in a Mustang Boss 302, a father and

son explore America's auto-racing history.

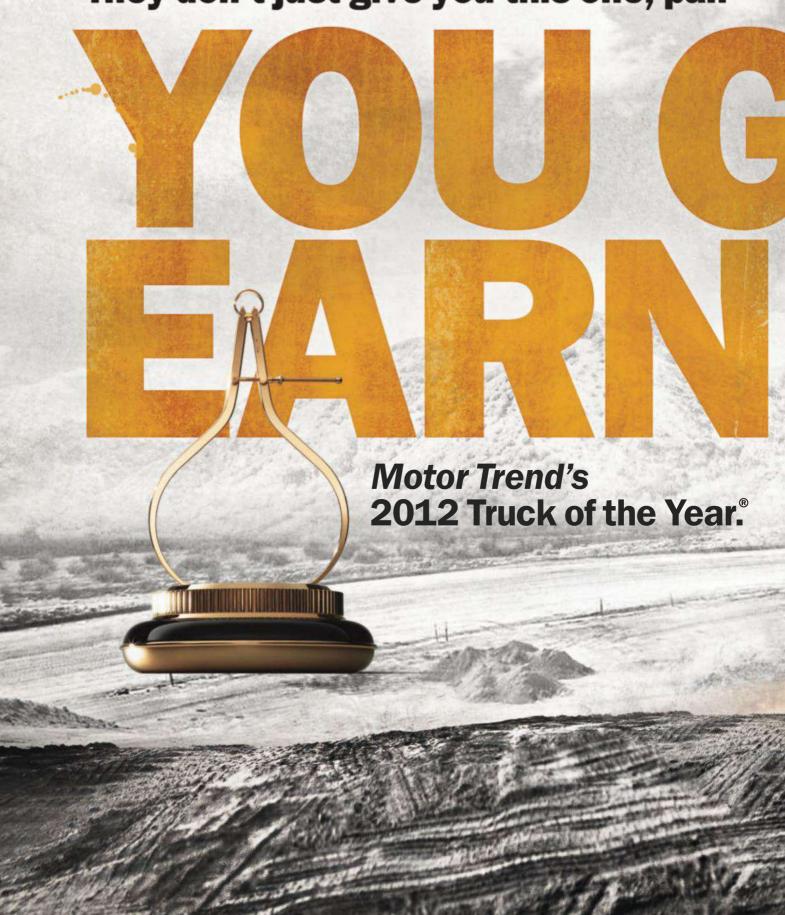
ON THE COVER

Bringing Special Operations forces to our cover shoot at Brooklyn's Fast Ashleys Studios proved troublesome, so we improvised. To help model Tim Ryan portray one of America's elite warriors, we armed him with an M4 carbine outfitted with a SOPMOD accessory kit-the same gear used by the 1st Special Forces Group in this month's cover story. Photographer Monte Isom nailed the shot.











New!

Popular Mechanics

weekend

23 Pages of DIY

ILLUSTRATIONS BY ROMUALDO FAURA (COMPLAINTS); ANTHONY VERDUCCI (PORTRAITS



/hat You Said

(ABOUT OUR MAY ISSUE AND MORE)

We read all of your comments, tweets, and letters to PM—even the ones written on light bulbs. Keep 'em coming!

TALK TO US

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CURATED BY ALYSON SHEPPARD

Our May issue inspired many insightful letters. Responding to our cover story, "Reengineering the Human," which predicted the obsoletion of prostheses in the next 40 years, Andy Prevelig of Tallahassee, Fla., had another idea: "Instead of trashing all of the mechanical and software creations in 2050, we should use them to make helper androids," he wrote. Arthur L. Cunningham of Delafield, Wis., appreciated our story on esoteric auto repair, "Brotherhood of the Wrench." "What a well-written article," he said. "There are many disparate West Coast niche restoration shops that enthusiasts should take the time to check out." "What Went Wrong: Cruise Ship Disaster" examined the *Costa Concordia* shipwreck.

104. Home

Pick the right landscape plan to fit your style and budget. Home Clinic Replacing handles on old tools.

118. Science

How to watch-and countfireflies to help researchers gather crucial data.

120. Auto

Real gearheads use air tools. We get you started on the path to pneumatic bliss.

Tactics 20 Ways to Save Gas Car Clinic Oil for Any Season

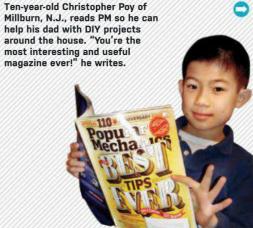
131. Adventure

The canoe-paddling method you learned at camp is wrong. Here's the right way.

134. Tech

How to edit your home movies and give them the polished look they deserve.

Early Adopter Build a boombox. Digital Clinic Power Sharing



O COMPLAINTS DEPARTMENT

Calling the Vespa GTS 300 Super a 'Prius beater' is absurd ("Six-Scooters," April). Can we please compare apples to apples, not apples to nuclear subs? The Vespa seats two to the Prius's five, and gets you wet when it rains." Bruce Johnson, Madison, WI



GREAT SOUND COMES NATURALLY.



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By combining analog vacuum tubes with digital technology you'll enjoy music and entertainment the way they were meant to be heard. The Samsung HT-E6730W Home Entertainment System comes with everything you need to fill your home with warm, natural, truly lifelike audio. Plus, the included Blu-ray $^{\text{IM}}$ player gives you access to the internet, apps and a world of smart content. Experience the future of home entertainment at **samsung.com/hometheater**.



"I'm glad the cruise-ship industry requires lifeboat evacuation drills before departing port, wrote David Gross of Tiffin, Ohio. "Ships should consider livening up presentations with onboard entertainers. Safety is a serious topic, but the audience needs to stay attentive." ● "I was surprised to see a picture of a Yankee screwdriver in DIY: Home (Yankee Dandy)," Bob Moore of Ontario wrote. "In Canada, Yankee screwdriver is our name for a hammer!" (Sorry, Bob, but we won't be provoked into cracking wise about Canadians.) • To the fan mail: "@PopMech has to be one of the best, if not *the* best, digital magazines in the iTunes Store!" Brad Chambers (@brad wchambers) tweeted. Bill Peterson (@thebillp) wrote: "I always travel with a copy of @PopMech. I consider this magazine my friend." Thanks, pal.

App-tastic! PM's Used Car Checklist Looking for a new (but experienced) ride? The "Popular Mechanics Used Car Checklist" just hit the iTunes Store. Written by our auto editors, the free app walks you through a 101-point inspection to help you get a good deal and avoid buying a clunker.

WHAT YOU SAID



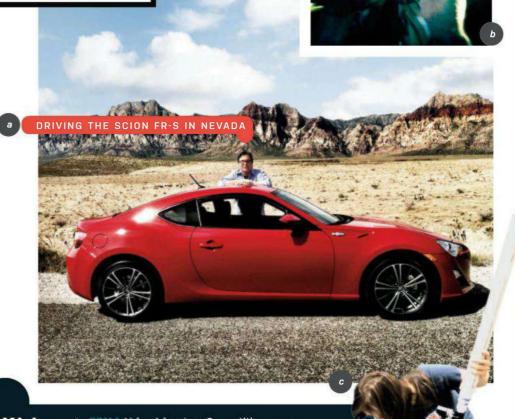
What We're Up To



(a) Special projects editor Joe Bargmann tests out the Scion FR-S in Red Rock Canyon National Conservation Area near Las Vegas.

(b) Senior news editor Joe Pappalardo peers through a nightvision monocular during a ridealong in a Special Operations forces' mine-resistant ambush-protected vehicle. Pappalardo reported from the Army's Yakima [Wash.] Training Center for our cover story, "Looking Downrange."

(c) Associate editor Erin McCarthy preps our homemade T-shirt cannon for blastoff at the USA Science &Engineering Festival in Washington, D.C.



JULY 1: Volvo Adventure Competition opens

JULY 4: Grilling and watching fireworks (that counts!)

JULY 23: Google Science Fair, Mountain View, Calif.

JULY 27: Opening of the 2012 Summer Olympics, London

JULY 28-29: Maker Faire Detroit, Dearborn, Mich.



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Employee of the Month



Robin Tribble keeps us from mangling the English language. Tops in her discipline, she ran an all-star panel on editing tablet apps at the 2011 American Copy Editors Society conference. She's also an avid quilter, currymaker, bowler, and online gamer.

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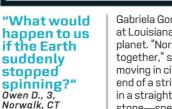
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THE KID WANTS TO KNOW

Are you a kid with a question? Ask us! Email popularmechanics@hearst.com.



Gabriela Gonzalez, professor of physics and astronomy at Louisiana State University, says we'd be hurled off the planet. "Normally, the Earth, us, and everything else rotate together," she says. So even if we're standing still, we're moving in circles. Think of us like a stone spinning on the end of a string. "When the string breaks, the stone flies off in a straight path," she says. In this case, we would be the stone—speeding through space at about 900 mph. Which would be cool, if you could survive. — Steve Rousseau



GNITION







Rust-Oleum's EPOXY SHIELD Garage Floor Coating brings the latest technology to your garage. With a simple roll-on application you can create a stunning showroom finish. And its unsurpassed performance is 100% guaranteed. So go ahead and add a new room to your house this weekend.



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AUTOMOTIVE SCIENCE TECHNOLOGY HOME HOW-TO CENTRAL VIDEO





ON THE WEB

The magazine you hold in your hands is just one piece of the PM universe. Visit PopMech.com to read the confessions of an email hoarder, see 10 perfect jobs for DIY beginners, and find great stories like these:

TOP CULT CARS

A car need not be a VW Beetle, Chevy Corvette, or Porsche 911 to have a legion of dedicated fans. There are plenty of cars that, while flying a little under the radar, still attract a passionate following. Here are 10: popularmechanics.com/cultcars

LOOK INSIDE AN AURORA

Ben Longmier became fascinated with the aurora borealis as a 10-year-old boy. Now he's a rocket scientist, but in his spare time Longmier recently took a team to Alaska to send balloons carrying GoPro cameras to record the aurora from the inside.

popularmechanics.com/aurora

WILD DIY GUITARS

The Gibson Les Paul isn't for everyone-some musically inclined DIYers just have to craft their own axes. These crazy homemade instruments need to be heard and seen.

popularmechanics.com/guitars



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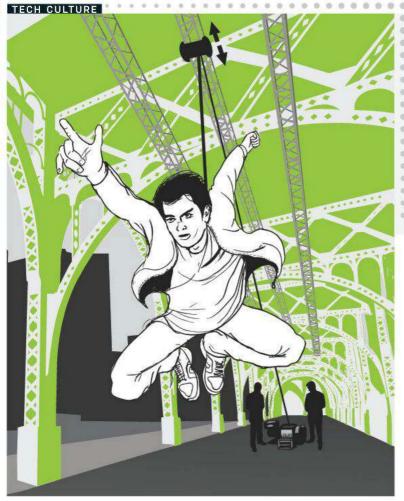
1. PORT Astronauts step into the full suit through the back port. This port will mate with the spacecraft, enabling an astronaut to enter the suit from inside the craft for extravehicular activity. Another advantage: When used in low to no atmosphere, the port conserves more air than a conventional air lock.

2. MOBILITY The Z-1 has bearings at the waist, hips, upper legs, and ankles to allow an astronaut greater mobility essential for retrieving soil and rock samples in tough terrain. 3. MATERIAL This provisional outer covering conceals a heavily engineered inner suit; a layer of urethane-coated nylon retains air, and a polyester layer allows the suit to hold its shape.



Americans have seen a TV weather forecaster mention global 58 percent would like to hear a forecaster talk about it.

A MARCH 2012 SURVEY found that 11 percent of Americans have seen warming five or more times in the past 12 months; 58 percent would li



HOW IT WORKS

- To begin swinging, an actor jumps off a crane wearing a harness that's wired to a pulley, in turn attached to an electronic winch.
- As he reaches the bottom-traveling 40 mph and pulling 3 g'sand begins to arc upward, an operator moves the pulley forward 50 feet. "It's like cracking a whip, where it goes along, stops, goes along, stops," says stunt coordinator Andy Armstrong. "We did that two or three times." The wires were erased in postproduction.

Full Swi



pider-Man would be nothing without his swing. To create the character's signature web slinging in The Amazing Spider-Man, out July 3, stunt coordinator Andy Armstrong studied slow-motion footage of gymnasts, then built one-of-a-kind rigs to allow actor Andrew Garfield and the film's stuntmen to emulate their motion. The team used the aluminum-truss system in many locations: One track, built under a bridge in New York City, was 180 feet long; another rig hung off an old firetruck to make it look as though Spider-Man is swinging through traffic. The system enabled director Marc Webb to get more realistic web slinging than ever before—a fact that delights Armstrong. "A lot of kids have grown up with video games and computer-generated characters," he says. "There's still something much more exciting about seeing a real human do something that we'd all love to do if we had the ability." — ERIN MCCARTHY



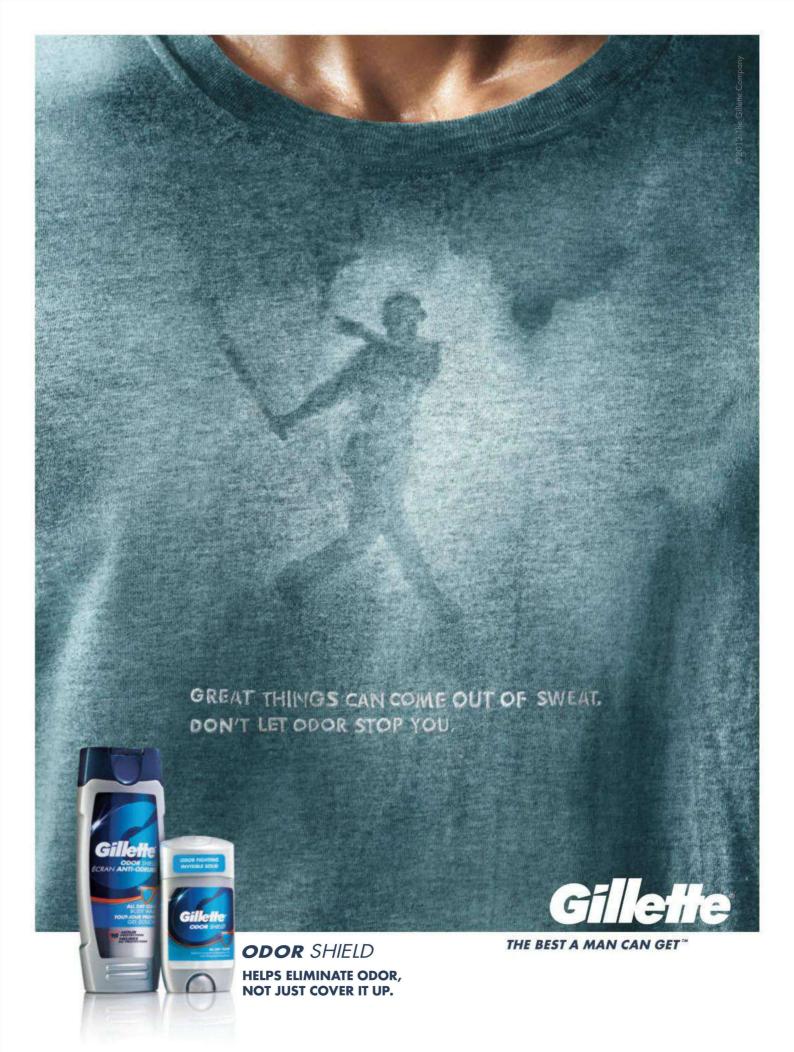






Every living thing on earth uses DNA or RNA to carry its instructions for life. These two nucleic acids are built from different sugars: DNA from deoxyribose and RNA from ribose. Now scientists have shown that at least six other types of sugars can form nucleic acid backbones—and they can be used to store and retrieve genetic information. Called XNAs (for xeno-nucleic acids), the new synthetic chains could address important questions about the origin of life. John Chaput, a team member and molecular biologist at Arizona State University, poses an even more tantalizing one. "Could you create synthetic life with it?" he asks. "That's possible, but it's much further down the road." - SARAH FECHT

DIAGRAM BY MARTIN LAKSMAN (XNA MOLECULE



60-SECOND GENIUS



Jon Mukand, M.D., author and principal investigator for BrainGate

Q. How is the human brain like a computer?

One major similarity is that both the brain and the computer have intricate circuitry; but the brain has many, many more connections because it contains 100 billion neurons.

The other similarity and we used this in research for the Brain-Gate—is the logical processing of information that occurs in both the brain and the computer.

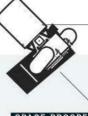
We placed an array of 100 electrodes, each thinner than a hair, in a paralyzed patient's brain, at the area that controls the hand. Then we recorded nerve signals from this array while asking the patient to imagine moving a computer cursor. The BrainGate software correlated specific patterns of nerve activity with specific intentions of the patient, and stored this information. (Brains and computers both have memories.)

When the patient wanted to move the cursor, the software figured out that X pattern of nerve activity meant the patient wanted to perform Y task: to check emails, control a TV, or even move a robotic hand.

— AS TOLD TO
DALENE ROVENSTINE

SPACE ENTREPRENEURS

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SPACE PROSPECTING

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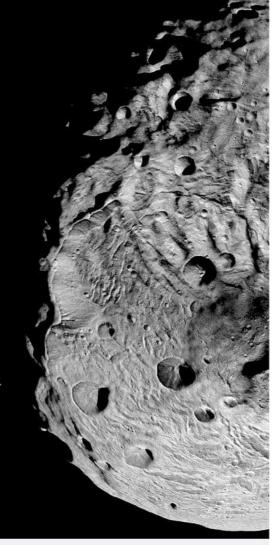
Future astronauts could use the 24,000 gallons of H₂O for life support or convert it into rocket fuel.

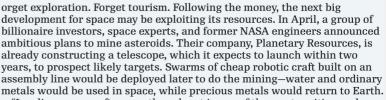
WATER

18%

IRON, NICKEL, COBALT

Nearly 100 tons of common metals could be used for spacebased manufacturing and for building space stations and habitats for colonies.





"Landing spacecraft on another planet is one of the most exciting and rewarding things you can ever do," Planetary Resources' president and chief engineer (and former JPL Mars mission manager) Chris Lewicki says. "But when you have an opportunity like we have to redefine how it can be done, that's really attractive." If the company succeeds, the payoff for investors such as Google's Larry Page and Eric Schmidt could be, well, astronomical. According to Peter Diamandis, CEO of the X Prize Foundation and a Planetary Resources co-founder: "A 500-meter asteroid of the [optimal] metal chondrite contains more . . . precious metals than have ever been mined in the history of humanity." That's awfully attractive, too. — MICHAEL BELFIORE



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Shape-Shifting Sand

How do you become the most popular kid at the MIT schoolyard? Build a giant box of "smart sand." Within moments, the sand will form a perfect replica of any object buried in it, scaled to whatever size is desired. At the university's Computer Science and Artificial Intelligence Laboratory, researchers have used 3D computer simulations to show that grains of smart sand can figure out the borders of the item to be duplicated, then communicate with one another to organize the copy. They also built prototypes—cubes of "smart pebbles" about a centimeter wide. Tiny processors and electropermanent magnets enable the pebbles to connect and disconnect from their neighbors on command. A.H.

JUST CURIOUS

Core Competency

PM TECH EDITOR GLENN DERENE NERDS IT UP WITH U.S. SECRETARY OF ENERGY **STEVEN CHU** ABOUT THE WORLD'S FASTEST COMPUTERS.

Have you had any personal experience with supercomputers in your research career?

When I was an undergraduate at the University of Rochester, I had a summer job where I programmed Control Data supercomputers. Later, when I was working at Stanford [University] and Berkeley [National Lab], I was on the board of directors for the graphics chip-maker Nvidia. Today, Nvidia's GPU chips are used in four of the top 10 supercomputers in the world.

Today's fastest computers operate in petaflops [10¹⁵ operations per second], and there's a national initiative to move toward exascale computing, which would increase processing speeds a thousandfold. How much computer do we really need?

When you're doing baby calculations—
Excel calculations and graphing—your laptop is all you really need. For solving differential equations, the current generation of supercomputers is pretty good. But once you go into big-time simulations—climate or jet engine or fuel injection—for the next factor of 100 to maybe 1000 you want more.

What effect have supercomputers had on global competitiveness?

[Supercomputers are] directly related to a country's industrial sophistication. But it's deeper than being the biggest guy on the block. At the DOE, we see supercomputing as being more and more of an industrial tool. The benefits filter down to everything from the aerodynamics of cars and trucks and airplanes to the efficiency of jet engines and highperformance buildings.



Hot Stuff

Using a realistic "robosquirrel"—a taxidermic ground squirrel with a mechatronic tail—a team of engineers from the University of California, Davis, and biologists from San Diego State University are studying the evolutionary arms race between squirrels and rattlesnakes. When the robosquirrel waves and heats its tail, mimicking the animal's behavior, snakes in the wild back off. This confirms that adult squirrels use interspecies infrared communication and that rattlesnakes rely on IR-sensitive pit organs more than their eyes. — ALEX HUTCHINSON







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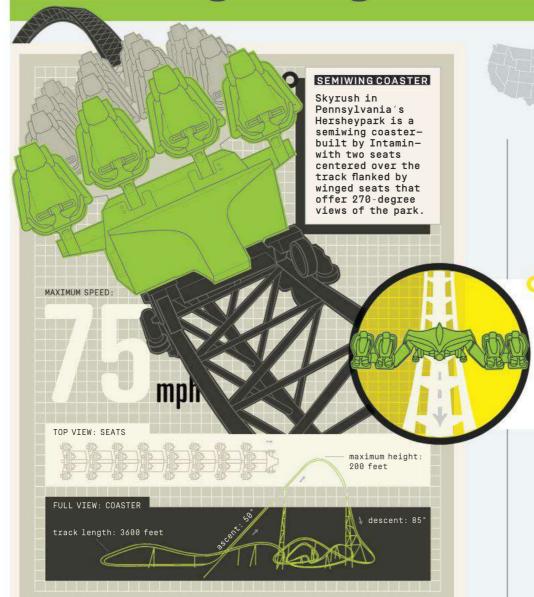


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ADVENTURE

Riding Shotgun



his spring, three U.S. amusement parks debuted a new breed of roller coasterdelighting adrenaline junkies and horrifying the friends they drag along. These wing coasters have cantilevered seats, which amplify their movement and better simulate the sensation of flight. Passengers experience up to 5 g's in three directions. Shifting people's weight from the center of the track posed engineering challenges: Loads on the floorless seats are nearly three times greater than on traditional ones, so Hersheypark chose to mill each 2-ton car frame for its Skyrush coaster from one large piece of steel. — ALLISON MCCANN

TRUE WING RIDER

ECH WATCH

Both Dollywood in Pigeon Forge, Tenn., and Six Flags Great America in Gurnee, Ill., opted for true Wing Ridersbuilt by Bolliger & Mabillardwith four fully cantilevered seats per row.

"It's the closest thing to flying. With the smooth sense of rolling, pulling of g-forces, and screaming dives—it feels very similar.' — MARK CUTMORE, FORMER RED ARROWS FIGHTER PILOT, ON TESTING A WING RIDER IN CHERTSEY, ENGLAND'S THORPE PARK IN FEBRUARY





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To learn more: 1-800-760-2749, ext. Q8517 Bose.com/headphones





ECH WATCH

When Norwegian Vikings sailed off to loot and pillage, they inadvertently took mice with them. By digging up the bones of ancient rodents and comparing their DNA to modern house mice, an international team of researchers is retracing the various phases of human migration across the Atlantic. Mice from 10th- to 12th-century settlements in Iceland and Greenland have the same DNA markers as the Viking stowaways. Today's mice in Iceland do too, with very little genetic variation in the population (just like the island's human population). In Greenland, on the other hand, modern house mice aren't related to the Viking species—a more recent wave of immigration wiped them out. Similarly, there's no trace of Viking DNA in house mice living in Newfoundland, the farthest west the Vikings reached. — A.H.

ATMOSPHERIC SCIENCE

Government Chemtrails (Really!)



Usually when strange cloud formations appear in the sky, anyone blaming government experiments can be easily dismissed as a paranoid crackpot. Not this time.

On March 27, NASA launched a volley of five rockets from its Wallops Flight Facility in Virginia. The rockets released a chemical tracer, called TMA, that produced milky clouds visible from Wilmington, N.C., to Buffalo, N.Y. But the purpose of the experiment was less nefarious than mind control or behavior modification: The agency wants to learn about the volatile high-altitude jet stream 60 to 65 miles above the ground.

Winds in the upper jet stream can exceed 300 mph, and strong electrical turbulence there can disrupt radio and satellite communications. By studying how the tracer clouds drifted apart, along with pressure and temperature data from sensors onboard two of the rockets, researchers will be better able to model this region of Earth's atmosphere.

- ALEX HUTCHINSON



TMA Trimethylaluminum produces aluminum oxide, carbon dioxide, and water vapor when it reacts with the air. NASA has used TMA to study the near-space environment for decades. It can burn skin, but NASA says the high-altitude release poses no threat.

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Head Strap Mount









This Sport Brella Chair XTR (\$65) has more bells and whistles than a boardwalk arcade. The 46-inch canopy rotates 360 degrees and tilts 180 degrees. The insulated side compartment stashes up to four beverages (okay: beer), one of which fits nicely in the armrest cup holder.



3 feet for larger ones.



BEACH BOOMER

Yamaha's rugged PDX-11 speaker dock (\$100) connects with any smartphone. The sound quality is clear and rich, and we like the remote—no getting up to change tracks!

SPRAY COOL

With a high-speed fan and up to 1.5 hours of use per refill, the Windchiller Personal Mister (\$25) produces cool vapors on even the hottest, sunniest days.

GOING DEEP

The fog-resistant coating on Liquid Image's Free-style 330 swim goggles (\$99) keeps the picture clear as you capture HD video and stills of your adventures in the surf.

A REAL LOOKER

Snap macro shots of seashells with Carson's MM-250 iPhone adapter (\$25) and MM-200 pocket microscope (\$19), which provides a 60x to 100x optical zoom.



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andymen used to hold a flashlight with their teeth to illuminate a work area. Blackfire's Clamplight [\$30] has a swiveling head and adjustable beam and can either stand on a surface or clamp to a shelf, freeing up a worker's hands and preventing jaw pain.

BLACK DIAMOND EQUIPMENT MAGNETRON ROCKLOCK

Threaded or spring-loaded sleeves secure the gate on most locking carabiners, which can be tricky to manipulate. The Magnetron Rock-Lock (\$25) simplifies the process with auto-locking magnets. To release, simply press inward. The clip can easily be opened with one hand but remains securely locked when closed.

BIOLITE CAMPSTOVE

The BioLite Camp-Stove (\$129) is a true multitasker. Igniting small twigs and leaves in the fire chamber creates thermal energy, which is converted into reusable energy that can power small devices hooked into a USB port—all while cooking your dinner. Collapsed, it's about the size of a large Nalgene bottle. But at 2 pounds, it might be a bit too heavy for campers on long-distance hikes.

SWIVL PERSONAL CAMERAMAN

How can you record video of yourself without looking like a total stiff? The Swivl Personal Cameraman (\$180) provides an answer. Slide your phone into the dock, snap the marker to your lapel or collar, and hit record. The lens follows the marker to keep you in frame. Destined to become a staple of vloggers and video chatters, the Swivl brings quality camera tracking to the masses.

THIS LIGHT BITES

UPGRADE



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Larry the Cable Guy Actual user

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HOW IT WORKS/Paint Sprayer



TECH & TOYS

Black & Decker's 2-Speed Quick Clean Sprayer (\$100) introduces two innovations that make painting everything from fences to sheds quicker and easier than ever. Here's how it works.





- Most sprayers require the operator to remove a canister and fill the reservoir from the top, which often leads to paint dripping from the draw tube and making a mess. Black & Decker's tool has a side-fill canister, which allows for quick, clean refilling.
- O Set the flow knob to the desired intake—the higher the number, the greater the amount of paint sucked up and pushed out of the system-and switch on the machine; this kicks the solenoid motor into action.
- The motor drives a piston inside the sprayer at up to 7200 pulses per minute, creating suction that pulls paint up through the draw tube.
- The paint travels past the piston to the atomizer valve, which moves in a swirl pattern to break up the paint for spraying.
- Finally, the paint moves through the spray tipchoose between horizontal, vertical, and round spray patterns—and coats the surface.
- To clean the machine without taking it apart, simply pour water into the upper reservoir, flip the switch from paint to clean, and spray.



Brushing is great in small spaces and on long narrow surfaces, such as trim or the corner where the wall meets the ceiling. A sprayer produces a high-quality finish-on kitchen cabinet doors or furniture, for instance-and is also a good choice for rough, weathered wood surfaces that can snag a brush or roller's fibers.



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GEAR UP Amateur Astronomy

If you want to wish upon a star, first you need to track it down. Here's your stargazer's starter kit. - DALENE ROVENSTINE

1. SCOPE IT OUT

Many avid astronomers start with the AstroMaster 114EQ (\$250). Markings on the equatorial mount aid object location; a 4.5-inch aperture brings planets, stars, and nebulae into clear view.

2. NIGHT LIGHT

Hands-free illumination is key when trekking to your star-watching spot and setting up. Petzl's Tactikka XP Adapt headlamp (\$60) also attaches to a belt or pocket; a red filter gives night vision.

3. STAR SEEKER

Find what you're looking for with Southern Stars' SkySafari 3 App for iPhone, iPod, and iPad. The basic version (\$3) has a built-in compass and gyroscope, and catalogs 46,000 objects.

4. COOL AID

The double steel walls of S'well bottles (\$35 for 17 ounces; \$45 for 25 ounces) keep liquids hot for 12 hours or cold for 24 hours sans scalded hands or slippery condensation.

5. BUG BLOCKER

In our test, body parts covered by Columbia's Bug Shield Mesh Jacket (\$90) were bite-free after 30 minutes in the woods at night. We wish there were a hazmat suit made with this fabric.

6. SOLID FOOTING

The best stargazing takes place off the beaten path (thanks, light pollution!). Navigate tricky terrain in L.L. Bean's comfortable-as-sneakers Waterproof Trail Model Hiker midcut boots (\$99).



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EDITOR TESTED

Thank you for the press release. We placed it in the recycling bin. We appreciate you providing the basic product information; it's helpful. But we have a job to do. Here's our candid take on that thing you sent us.

SNOW PEAK AJIKATAYA HATCHET

NOT YOUR ORDINARY CHOPPER

When I'm channel-surfing and a late-night infomercial about knife collecting comes on, my hand freezes on the remote. You may picture me now, with an "L" for "Loser" tattooed on my forehead. But I find the knives and the cheesy sales pitch transfixing. Similarly, the Ajikataya hatchet (\$140) by Snow Peak cast a spell on me when it arrived at the office. No one in his right mind would pay \$140 for a hatchet. But grip the sculpted white oak handle. Behold the subtle arc of the blade, which is forged in Japan using a centuries-old method. Check the edge. Think about shaving with it, but don't—it's a hatchet! In my backyard I quickly carved a pile of branches into kindling. I used the lovely blade to whittle 2 x 2 lengths of pine lumber into easy-to-drive garden stakes. Power, precision, balance, history. Call me crazy, but I'm sold. — Joe Bargmann

LONG-TERM GADGET TEST

DEVICE: NIKE+ FUELBAND

PRICE: \$149

TESTER: GLENN DERENE

TIME TESTED: ONE MONTH

WHAT'S IT SUPPOSED TO DO?

The FuelBand is a water-resistant clip-on electronic bracelet with accelerometers, a Bluetooth wireless antenna, and an LED dot-matrix display. A button togles the display to Steps, Time, Calories, and NikeFuel, which is the company's own normalized measure of activity, regardless of the user's body mass.

HOW DID IT PERFORM?

The FuelBand is sturdy and comfortable. Its presence on your

wrist inspires you to move more smoothly. It can also be synced with an iOS device and computer to graph your progress toward your fitness goal. The problem is, regardless of how much science goes into Nike's algorithm, the NikeFuel metric feels arbitrary. The software allowed me to set my own goal of 2500 Fuel points. When I reached that goal, the display rewarded me with a celebratory animation, but I had no idea if I had achieved a healthy level of activity. — G.D.





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HORSEPOWER PUMPS

TO GET BOTH FUEL ECONOMY AND HORSEPOWER, AUTOMAKERS ARE BOOSTING ENGINES WITH PUMPS THAT PROVIDE EXTRA KICK WHEN NEEDED.

ig engines provide a satisfying surge, but most of the time we're using only a fraction of an engine's maximum power. To increase fuel economy, automakers are rapidly employing smaller engines—both in displacement and cylinder count. Downsized engines can, however, produce big-motor power with the help of pumps that force more air into the engine. The extra air, combined with fuel, makes a

more powerful "boom" when the spark plugs fire, increasing horsepower.

Automotive engine pumps come in two flavors: turbochargers and superchargers. Turbos are currently the de facto smallengine power booster because they efficiently run off the engine's exhaust. This energy may be "free," but there's a slight delay between the time the driver presses the gas and when the turbo



almost certainly be boosted by the

end of the decade.

2013 Lincoln MKS

2013 Infiniti

JX35

Ducati 1199

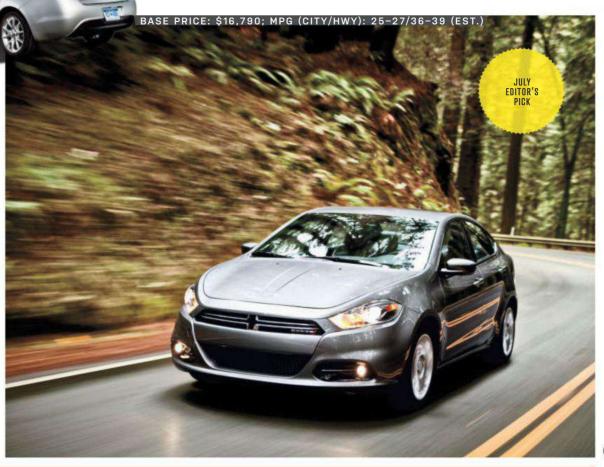
ments like helical rotors and a

bypass system for coasting have

TEST DRIVES

o 2013 Dodge Dart

odge went without a traditional compact sedan for nearly seven long years. But now, thanks to an infusion of small-car know-how from parent company Fiat, there's a new Dodge Jr., built largely on the bones of the Alfa Romeo Giulietta. To make sure there's enough room for us girthy Americans, the Giulietta's chassis has been widened and stretched. But despite the increased size and heft, it's clear Dodge has a driver's car here, one that's extraordinarily well-composed. The suspension has just the right amount of compliance over the rough stuff, but it's firm enough to handle hard cornering, with superb feedback from the electric power steering. Of the three offered engines, you'll want the optional turbocharged 1.4-liter in the SXT model that's priced from \$18,790. It produces the same 160 hp as the base 2.0-liter, spits out 184 lb-ft of torque (versus 145 lb-ft for the bigger mill), and has superior fuel economy: 39 mpg on the highway. Inside, the Dart has soft-touch materials placed wherever a hand or elbow may fall. If this little sedan is any indication, future Chryslers will have a welcome hint of European élan. - BEN STEWART



GLOSSARY

DESMODROMIC VALVETRAIN A system where there is no spring holding the valve closed. A rocker arm opens the valve and another closes it. The valves, therefore, always faithfully follow the cam lobes. The term desmodromic derives from two Greek words: desmo [bond] and dromos [path]. Ducati says the system provides more precise high-rpm valve actuation. That was true in the '50s, but today desmo is probably more effective as a marketing tool.

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AUTO INTEL

2013 Ford Escape

After 11 years, there's finally a third edition of the Ford Escape. The truckish appearance and clunky dynamics are out, and the 2013 crossover gets taut handling with quick steering and little body roll. Some buyers may find the ride a bit too stiff, especially on over-pocked and potholed roads. There's a choice of three engines, but we prefer one of the two turbocharged EcoBoost four-cylinders-a 1.6-liter with 178 hp or the 2.0-liter with a full 240 hp. The 1.6-liter may sound undersized, but in reality the little tyke does a commendable job moving the

Escape. It's only when you need a boot full of throttle that you'll wish for more thrust. Or if you want to raise your heart rate: Pitch a 2.0-liter Escape deep into a corner and let the all-wheel-drive system sort out the power—you'll pull through without any drama. If you're aiming for fuel economy, buy the new 1.6. It gets an estimated 33 mpg (versus 28 mpg from the highest-mileage 2012 Escape), thanks in part to grille shutters that close at freeway speeds to improve aerodynamics. Smart. — BEN STEWART

2013 Infiniti JX35

What's new: Infiniti's first three-row crossover. Available with front- or all-wheel drive.

Driving character: Exceptionally quiet with smooth ride quality. Steering, however, is novocaine numb.

Roadblock: Engineers tuned the 265-hp V-6 and CVT for fuel economy but left out punch.

Latest march toward full

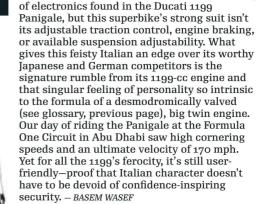
computer control: Optional Backup Collision Intervention system automatically hits the brakes if it computes an impact is imminent. **Alternatives:** Over a dozen in the class. The JX is stuffed with standard features, but we still prefer the blue-collarish Dodge Durango.

TEST DRIVES

Ducati 1199 Panigale



PRICE: \$17,995; MPG (CITY/HWY): N/A



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TEST DRIVES

2013 Lincoln MKS



With the Town Car's demise the MKS now reigns as Lincoln's biggest sedan, and it actually grows a little for 2013, with an elegant interpretation of Lincoln's split-wing grille adding 1.8 inches to its length. Beyond cosmetics, the biggest change is a new, standard Continuously Controlled Damping system that monitors shock settings over three driver-select presets (comfort, normal, and sport) and can vary responses up to 50 times a second. Thanks to the addition of the 3.7-liter V-6 from the Mustang, base-engine horsepower jumps significantly, from 274 to 304 hp, while overall fuel economy also jumps 2

mpg. The optional 3.5-liter twin-turbo V-6 gains 10 hp, to 365. Both engines are mated to six-speed automatic transmissions and front- or all-wheel drive. The big Lincoln isn't especially agile, and what sportiness it has is undercut by steering that lacks strong feedback. The sedan's raison d'être, however, is luxury, not bisecting apexes, and it shines more brightly in that department, with a very posh interior. The rebooted MyLincoln Touch infotainment system responds quicker to touch commands, but it still takes practice to master all the features. - TONY SWAN



2013 Ford Focus Electric



What's new: Runs on electrons thanks to a 141-hp electric motor and 23-kwh lithium-ion battery pack.

Neat trick: With a 240-volt 32-amp charger, reenergizing the battery takes just 4 hours.

Driving character: Drives like the impressively refined and sprightly Focus, though a little lighter on the sprite.

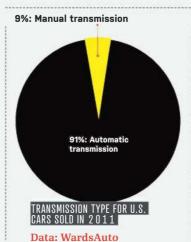
Roadblock: Like all EVs, trip planning is critical. The range is about 76 miles. Possible alternative: A \$17,295 base Focus that can refuel in under 5 minutes and go 400 miles on a tank.

WHEELHOUSE

Sign of the times These automakers have research centers in Silicon Valley: Ford, BMW, Volkswagen, General Motors, and Mercedes-Benz.

Percentage of cars sold by each automaker in California that must be zero-emission-EV, a plug-in hybrid, or hydrogen fuel cell—by 2025, as mandated by the California Air Resources Board (CARB).

The year CARB enacted its first EV mandate, which required that 2 percent of cars sold in California be zero-emission vehicles by 1998. The rule was dropped in 1996 due to concerns that EV technology wasn't ready.



Average price of a new vehicle sold in the U.S. in March 2012, setting an all-time record, according to price-tracking website TrueCar.com. The average for the previous March was \$28,771.

Only 35 percent of people who owned a hybrid bought another when new-car shopping in 2011, according to research from R.L. Polk. With improved internal combustion engines getting comparable mileage, the price premium might be a deterrent.



AUTO INTEL



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GRILLE TO GRILLE

SMART PLAY

Need proof that you don't have to drop a lot of dough for a quality new car? We tested three budget compacts on the roads around L.A.

AUTO INTEL			
	CHEVY SONIC LTZ	KIA RIO	TOYOTA PRIUS C
BASE PRICE/ AS TESTED	\$17,235/\$18,695	\$18,450/\$23,050	\$19,710/\$24,290
STANDOUT FEATURE	Drives like a sports car.	Looks fit for the Riviera—the good one in Italy.	No matter how hard we flogged it, it still averaged 44 mpg.
POWERTRAIN	138 hp, 148 lb-ft; 1.4-liter turbo- charged I-4/6M	138 hp, 123 lb-ft; 1.6-liter I-4/6A	73 hp, 82 lb-ft; 1.5-liter l-4; 60 hp, 125 lb-ft; electric motor, CVT
INTERIOR	Out of the three, only the Sonic's back seat is adult-friendly, with tall rear doors and a high ceiling that eases access and increases comfort.	The Rio's sexy, raked roofline is sweet—if you're the driver. And we dig the racy toggle switches used throughout. Those in steerage have to fold themselves and duck to enter the back seat.	The C offers average roominess for the class, but engineers have carved out a surprising amount of storage. We counted nine different cubby spaces in the cabin.
0-60 MPH (SECONDS)	8.36	9.72	11.31
DRIVING CHARACTER	Unexpectedly refined, nimble, and eager.	Tries, but mostly fails, to live up to its good looks.	Indifferent.
HANDLING	The suspension is both compliant and precise—a rare combo.	Too soft for spirited driving. It bobs on its springs and requires constant steering corrections.	Utterly forgettable. There's more enjoyment monitoring the variety of fuel-economy meters.
WEIGHT (POUNDS)	2880	2660	2600
TRANSMISSION	The six-speed manual is an extra \$700 and worth every cent. Plus it gets 6 percent better fuel economy versus the automatic.	Want leather and a six-speed manual? Denied! The cheaper Rio LX's six-speed manual gearbox can't be paired with upgraded seats and navigation.	Ask this CVT to accelerate the car to 70 mph and the engine bay moans and drones.
BRAKING, 60–0 MPH (FEET)	118.4	124.04	123.89
ENGINEERING TRIUMPH	A domestically produced small car that drives like it came from Europe.	Umm	The Prius has an electric motor and a battery pack, yet is still the lightest of the three.
EPA FUEL ECONOMY (CITY/HWY)	29/40	30/40	53/46
PM FUEL ECONOMY	34.40	36.50	44.30
THE BOTTOM LINE	We'd buy it simply for its driv- ing dynamics. Add in the roomy rear seat, crisp exterior, and value pricing, and it's a runaway winner.	Kia nailed the appearance portion. Once the company tackles performance issues such as steering feel and handling poise, it could rule the industry.	Perfect for technoheads mainly interested in mpg.

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"We wanted it to look like an organism, not a machine." Ralph Gilles

D. Side gill
The side gill is unmistakably a Viper cue and helps remove air pressure and heat from the engine bay. This gill is almost two and a half times as wide as it's ever been, and 100 percent functional. In the past, it's only been decorative.

E. Differential cooling ducts

A performance car's differential works hard and gets pretty hot-almost hotter than any other part—so we designed an air path for cooling. The ducts also modernize and lengthen the canopy of the vehicle.

F. Roof tab

The tab that extends off the roof accentuates the double bubble and minimizes the appearance of the rear window. This gives the rear wheel arches prominence; they bulge because that's where the power comes from-the rear wheels.

G. Diffuser

The diffuser is a huge contributor to the downforce of the back of the car. I'm very proud of it. While it looks sculpted, it's completely functional. We have integrated backup lamps that are kind of hidden in there.





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Tire pressure gauge

GPS navigation unit and a backup road atlas

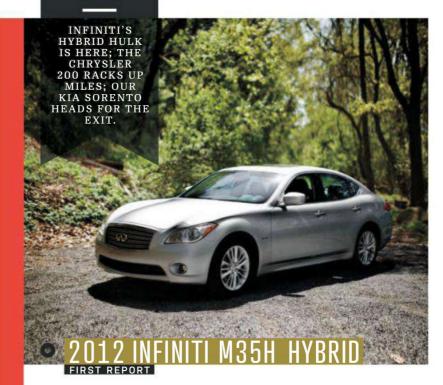
Mobile phone car charger

Snacks and plenty of water



Mobil 1 keeps your engine running like new.

POPMECH FLFFT



AUTO INTEL

an a full-size sedan deliver fun performance, luxury, and good mileage? That's the tricky combo Infiniti tries to nail with the M35h Hybrid. Here's our take after three months: Performance-wise, there is no disguising the heft of the lithium-ion battery pack when turning the wheel, but in a straight line, the two motors—gas and electric combine for, ahem, electrifying acceleration. Luxury is present in spades with rich interior appointments and crisp Bose sound. The mileage, naturally, depends. Driven gingerly in Eco mode (a setting that combats lead-footing so aggressively it seems like the gas pedal is pushing back), the M returned 30 to 32 mpg in mixed driving. Spirited driving in Sport mode (ahh, that's better) yielded 24 to 26 mpg on the same commute. Not bad at all, considering the vehicle's size, though not the kind of numbers that will impress your Pious—we mean Prius—driving neighbors. But the M excels at higher speeds, seamlessly layering the electric motor's 199 lb-ft of torque atop the V-6's already adequate power. And the fun of that doesn't get old. — JIM MEIGS

VITAL STATISTICS

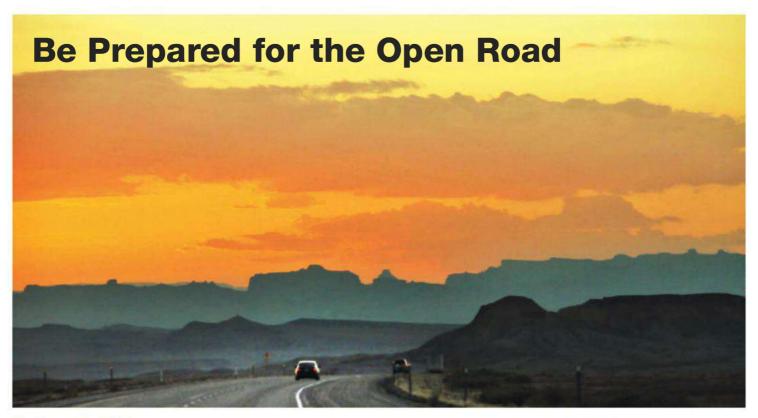
BASE PRICE **▶ \$53,700**

AS TESTED ▶ \$65,955

EXTRA-COST OPTIONS Blind-spot and lane-departure warnings, Intelligent Cruise Control, Bose audio system, 8-inch touchscreen, navigation, 18-inch wheels

DRIVETRAIN • 3.5-liter V-6 (302 hp, 258 lb-ft) with electric hybrid assist (67 hp, 199 lb-ft), 7A, RWD

COMBINED POWERTRAIN PERFORMANCE ▶ 360 hp





Learn more about Mobil 1 Extended Performance motor oil at mobil1.us Before any long road trip, it's worth having a mechanic check that all your car's vital systems are in top shape. These key elements include brakes, hoses, belts and the various fluids—from engine oil to coolants—that make your car perform as it should. You could do this yourself, but you'll spend the first 100 miles worrying you missed something.



The emergency kit your father kept in the

trunk still has its place. It should include old standbys like jumper cables, flashlight, duct tape, tire sealant, flares and a multi-function tool. But you're not driving your father's car anymore, and there are some things the modern driver should have on hand.

Before you hit the open road, check Apps like GasBuddy to find the stations with the lowest fuel prices. Have others in the car help find other Apps that can help with roadside assistance to tips on which services are available at the next exit.

Your cell phone isn't much good, however, if the battery is exhausted. A car charger for your phone is a must, but also bring an external battery pack in case the car battery fails.

Enter GPS navigation directions before you start driving so you don't wind up in the right town but the wrong state. Also, carry a backup road atlas in case GPS mapping software mislabels a road or routes you incorrectly.

Get a tire tread/pressure gauge with a digital readout. You'll spot tire wear faster and you'll be sure the tires are properly inflated for optimum gas mileage.

Lastly, obtain a NASA-developed solar blanket that reflects 90 percent of your body heat in case you're exposed to the elements. And make sure to pack water and energy bars. You can't think straight in an emergency if you're hungry and thirsty.

Whatever you do, be sure to use Mobil 1 Extended Performance motor oil. Proven to protect for 15,000 miles between oil changes.



In its first review, the 200's big trip was to Toronto. Now the stylish sedan has survived a marathon 2500-mile round-trip dash from New York City—through a mid-Atlantic snow-storm—to the Gulf Coast. The steering is smooth, and the car grips both icy interstates and blistering country roads with ease, thanks in part to its revised suspension. But after six months, we're wishing we had gone all in for the peppier 283-hp 3.6-liter V-6, as the 2.4-liter four-cylinder's pickup feels painfully sluggish at times. The smaller engine has, at least, often returned fuel economy in the high twenties. As for the infotainment and navigation system, the 200 has not been upgraded with Chrysler's latest Uconnect system, so we're left with a primitive nav screen. And one staffer had to have the computer reset after the system went rogue and ate a CD. Overall, however, the 200 has proved itself a comfortable ride over a long haul. — ALYSON SHEPPARD

DRIVERS NOTEBOOK

- Two PMers have reported problems with the engine stalling and the transmission acting a bit wonky, so we'll definitely get this checked out at the next oil change.
- The 200's interior was retooled last year, but we found many of the additions to be less than sophisticated, such as the manual dash clock that glows in the dark.

DATA SO FAR

AS TESTED ▶ \$19,745

PREVIOUS REPORT ► 04/12

MILES DRIVEN ▶ 10.953

MILES SINCE LAST REPORT ▶ 10,953

AUTO IN

FUEL ECONOMY ►
Average—23.9 mpg
Worst—18.9 mpg
Best—30.3 mpg

MAINTENANCE/REPAIR SINCE LAST REPORT ► \$101.14



2012 KIA SORENTO SX AWD



ith this third and final review, we bid a fond farewell to the Sorento as it leaves the PopMech fleet with generally positive staff reviews after almost 13,000 miles of testing. Nearly every driver commented on the Kia's power; for example, this reviewer noted "a lot of giddyup from zero to whatever." But we also found that the car's muscle sometimes proved a poor match for its light steering and soft ride. That said, the Sorento performed well in a variety of weather conditions. It's a solid road-trip vehicle—smooth and quiet on the highway. As a commuter ride, this SUV also stood up well: The voice-command phone interface and sweet Infinity sound system drew positive comments, but one reviewer said the "interior ergonomics feel clumsy and cramped." But when spring yardwork season rolled around, the voluminous interior accommodated 12 bags of mulch, four bags of compost, four chunky bales of peat moss—all that, and two big standard poodles. Overall, it's difficult not to like the Sorento—a solid entry in the reasonably priced three-row-SUV category. - JOE BARGMANN

DRIVERS NOTEBOOK

- The hard-shifting transmission was smoothed by a dealerprogrammed software update—under warranty.
- The shift-interlock system, which holds the transmission in park, is noisy—even after the shifter was replaced.

END DATA

AS TESTED ▶ **\$37,150**

PREVIOUS REPORTS DI/12, 04/12

MILES DRIVEN ▶ 12,707

MILES SINCE LAST REPORT ▶ 5381

FUEL ECONOMY ►
Average—20.0 mpg
Worst—13.1 mpg
Best—23.9 mpg

MAINTENANCE/REPAIR SINCE LAST REPORT ► \$35.87

OVERALL ▶ \$35.87



Feel Like You're Defying Gravity

This is my story

I used to be more active. I used to run, play basketball, tennis; football... I

was more than a weekend warrior. I woke up every day filled with life! But now, in my late 30's, I spend most of my day in the office or sacked out in front of the TV. My energy has fizzled and I'm embarrassed to admit that I've grown a spare tire (I'm sure it's hurting my love

life). Nowadays I rarely walk. For some reason it's just harder now. Gravity has done a job on me.

Wear them and you'll know

But that's when a friend told me about a new kind of shoe. A shoe biomechanically engineered to make standing and walking on hard surfaces like concrete, tile and linoleum easy. They defy the force of gravity by absorbing harmful impact and propel you forward maximizing energy return. The longer he talked, the more sense it made. He was even wearing a

Excitement swept through mv bodv

I received my package from GravityDefyer.com and rushed to tear it open like a kid at Christmas. Inside I found the most amazing shoes I had ever seen - different than most athletic shoes. Sturdy construction. Cool colors. Nice lines... I was holding a miracle of technology. This was the real thing.

GDefy Benefits

- Absorbs Harmful Shock
- Have Instant Comfort
- Improve Energy Return
- Appear Taller
- Cools Feet
- Reduces Foot Odor
- Customize Your Fit Accommodate most orthotics

the can! I put them on and all I could say was, "WOW!" In minutes I was out the door. I was invincible; tireless in

NDEFYER

Energy without

my new Gravity Defyer shoes. 4 out of 5 customers purchase a 2nd pair within 3 months.

Years of feeling exhaustion seemed to slip

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So, my friend, get back on your feet like \ I did. Try Gravity Defyer for yourself and live better, one step at a time.



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pair himself!

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Smart Memory™ Master Spring

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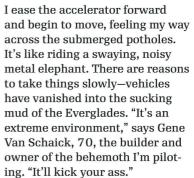


I'll Try Anything

BY JEFF WISE

PM'S REPORTER TURNED OFF-ROAD WARRIOR NAVIGATES THE EVER-GLADES IN A DIY BUGGY.

The 5000-pound metal beast pitches me forward as it lurches to a stop. Eight feet below, swamp water sloshes in front of our 4-foot-high tractor tires, rousing an alligator that wriggles away for cover.



I've met up with Van Schaick to experience the landscape he loves best-the wetlands of southern Florida-aboard the machine he's most passionate about: the swamp buggy. Most Americans tend to associate "swamp" with words such as "stagnant" and "malaria" and think of swamp buggies as dirt-flinging hot rods that race up and down mud wallows. But Van Schaick's swamp buggies are slow, utilitarian vehicles, and as for the swamp-well . . . "I don't know what people think of when they trash-talk swamps," he says. "I love the swamp. I love the views. I love the smell."

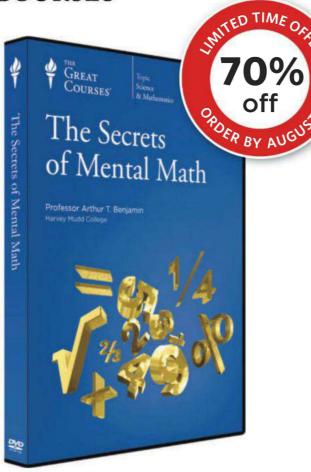
One point he'll concede: The swamp is hard to navigate. In recent geological time the area was limestone and coral reef, and it's still so flat that the torrential rains of summer and fall are slow to drain. For all but a brief dry season, waterlogged marshes and open water predominate. Anyone trying to hike in has to contend not only with the sheer physical exertion but dense vegetation, hungry alligators, clouds of mosquitoes, and four kinds of poisonous snakes.

For all its rigors, the back-country has much to offer in the way of recreation; though an easy drive from Miami, it's full of game to hunt, as well as exotic specimens to lure the bird-watcher and flora enthusiast. To tap those opportunities, intrepid Floridians began a century ago to retrofit

Model A and T Fords with big wheels and extra-low gearing. Today, a small but passionate subculture of builders—including a group founded by Van Schaick in 1990—carries on that legacy.

On a warm day in early February, Van Schaick takes me to a lot at the edge of an airstrip halfway between Miami and Naples, Fla. Some two dozen beefy, hard-driven machines are lined up, each one unique, having been designed and cobbled together—mostly out of plate metal and parts of other vehicles—by one of the 65 members of his club.





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Van Schaick, a retired carpenter, spent six years building his behemoth, Gray Ghost. The Goodyear tires yield 27 inches of clearance. The solid-steel tie rods are behind the axle for protection against cypress knees, the club-like growths that sprout from the roots of cypress trees. (If the knee hits the axle first, it won't be able to take out the tie rods.) The engine is a 2.8-liter V-6 from a 1982 Chevy Citation, without the fuel-injection system—Van Schaick stripped it out and replaced it with a carburetor. "Everything needs to be rugged and simple," he says, "so you can fix it while standing in 3 feet of water."

Van Schaick and I clamber on top of the buggy, which, from up here, looks like a boat—fitting for a vehicle that can negotiate 6 feet of water. I fire up the engine and we head out.

Past the parking lot are 38 square miles of county-owned land. Though the landscape is nearly identical to the federally administered Big Cypress National Preserve next door, there are fewer restrictions on its use. Soon we're axledeep in muddy water, moving across the cypress prairie. The landscape looks like something out of Dr. Seuss, an expanse of twisted gray trunks garlanded with bushy bromeliads bearing spiky red flowers. Farther on, the road becomes hemmed in by a forest so dense it feels like we're driving through a tunnel. Our wheels churn up mud the consistency of brownie batter. We never move faster than walking pace, and after an hour and a half we've covered only 5 miles.

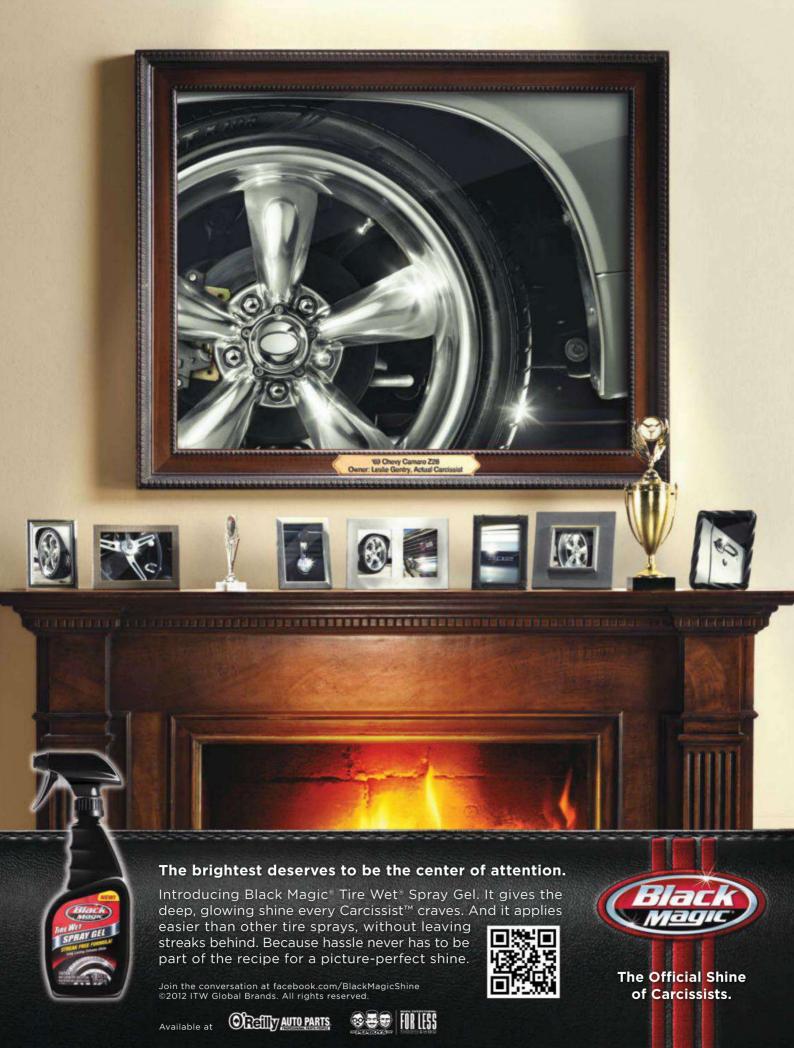
Van Schaick takes the wheel and gives me a tour, from the high ridges and island-like hardwood hammocks that remain partially dry year-round to the sediment-filled saw-grass ponds that during the wettest months become, as he puts it, "bottomless." Van Schaick has seen lots of things in these wetlands over the years. Once he surprised a panther while on foot. "It was less than 10 yards from me," he says. "It went straight up, turned in the air, and headed the other way."

I'm surprised at how pleasant it is. There's no oppressive stench; the water in the Everglades isn't stagnant but part of a broad, slow-moving flow. Snakes and alligators thrive here; so do deer, wild hogs, and turkeys. Without buggies, much of this verdant wilderness would be all but inaccessible. "It's uncomfortable for hiking, and it's easy to get turned around," Van Schaick says. "Anyone who doesn't know the area well isn't going to be able to penetrate the interior."

Nevertheless, the machines have their detractors. "They are detrimental to the environment," says Matthew Schwartz, executive director of the South Florida Wildlands Association. "The ground is very fragile, and when you put that much weight on it, the soil doesn't recover. It erodes right down to the limestone." Schwartz's group wants to keep motorized recreation from expanding within Big Cypress. But Van Schaick counters that most of the soil eroded by swamp buggies is replenished during each yearly cycle of flooding.

As we stop at a saw-grass pond and kill the engine, we can imagine that except for the machine under our butts, there is no sign of civilization. We could be in some remote wilderness, not an hour from one of the East Coast's biggest cities. A breeze moves across the tall green stalks of the saw grass, bearing a sweetly resinous tang. Overhead, two hawks coast, circling stiff-winged on the warm air. "I love the tranquility of this place," Van Schaick says. "Apart from the buggy tracks, it's just the way it's been for hundreds of years." **PopMech**

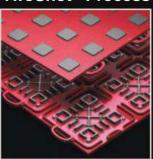




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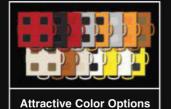
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THE WELL-EQUIPPED

GARAGE

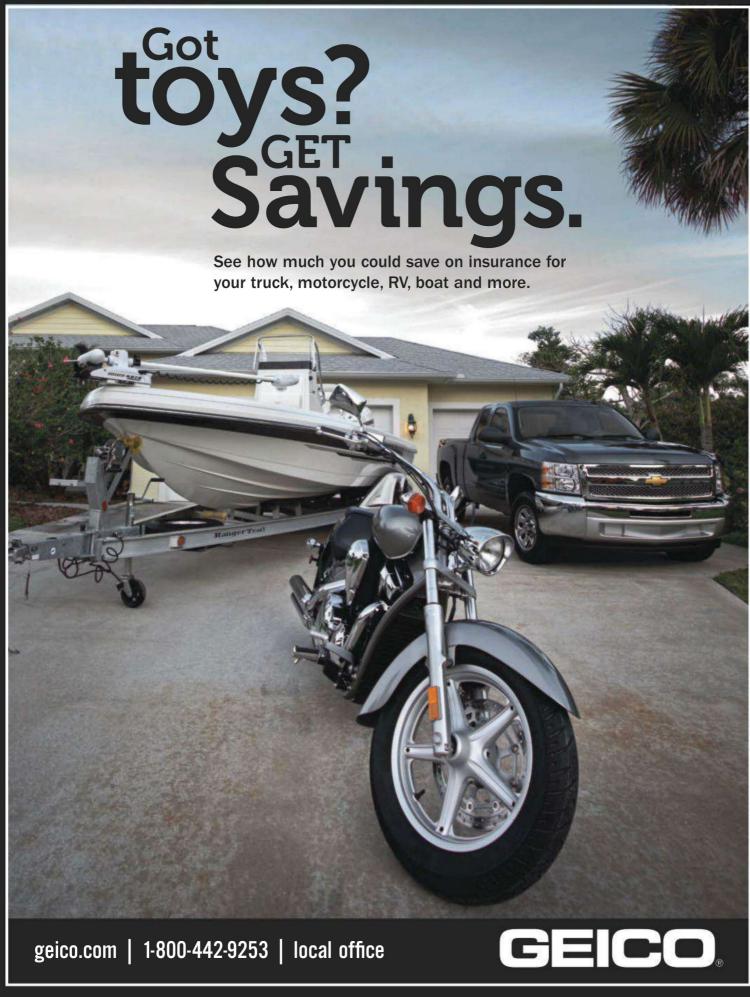
To those who love tinkering, the garage can be many things: a sanctuary, a place for quality time with your favorite toys, an alchemist's lab where beer turns ideas into reality. Whatever role the garage plays in your life, it's easy to see its potential as more than just a place to park. It calls out to be used, and to be useful. We offer the following pages as a guide to stocking your garage with the right tools, from the smallest hand-held items to the big gear that will make your neighbors jealous. IT'S TIME
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BROOMS,
AND BIKES.
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The most amazing thing in this garage is parked on the ceiling.









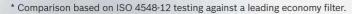


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ADD THIS STUFF

From must-have items such as a torque wrench and an oil-drain pan to useful gadgets like a multimeter, there are an endless number of ways to fully equip your garage. Do it right and you'll be able to tackle almost

any task life throws at you, or at least the ones that can be solved with elbow grease.

☐ SCAN TOOL

Why is your "check engine" light on? It's easy to find out, and even if you can't fix it yourself, this tool will keep the mechanic honest.

☐ OIL-DRAIN PAN

Think of it as a bedpan

for your vehicle.

☐ SOLDERING IRON

TOOL TIP: OIL-FILTER WRENCH

No matter how gently you first screw them on, oil filters are almost always a pain to remove. Which is why you need an oil-filter wrench. Two useful styles are pliers [1], which grab hard; and swivel [2], which works well in tight spaces.

☐ MULTIMETER

☐ TABLE VISE

It's like having an extra hand that is heavy and very accomplished at squeezing.

> A figurative flashlight for automotive electronics, this device measures voltage, resistance, and current.

☐ WIRE STRIPPER/CUTTERS

Cood for spills:

Good for spills; no substitute for an actual toilet.

☐ MECHANIC'S CREEPER

C-CLAMPS

□ BENCH GRINDER

Use this to clean, polish,

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☐ TORQUE

WRENCH

Whether it's for properly tightening lug nuts or bolting down a cylinder head, this tool lets you dial in a precise amount of torque. Digital versions cost more but are idiot-proof.

Are you working under that car or just napping? Bring your **WAND LIGHT** and **GLOVES** as an alibi.

next page THE BIG STUFF >

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Now that you know what it takes to expertly equip your garage, you'll want to be sure to have the right gadgets to get your tasks done. We recommend these most essential products—a perfect mix of tools to tackle a variety of auto DIY projects.

Meguiar's Professional Dual Action Polisher





Equus 3160 Diagnostic Code Scanner



Battery Tender Plus 12V Charger



Risk Racing Mine Light

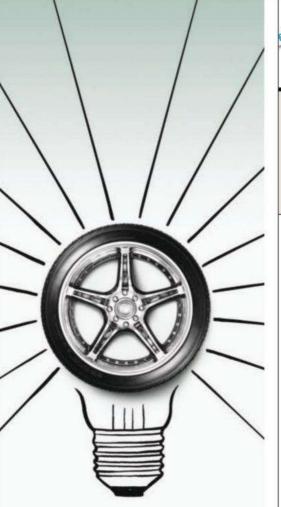






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THE WELL-EQUIPPED GARAGE

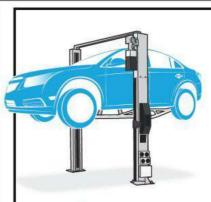
GET LIFTED

The lift is the holy grail of the amateur mechanic's garage. It makes simple tasks easier and complex tasks possible. A lift is a big deal to install; you might even need to repour your concrete floor. Here are four common styles to consider:



□ FOUR-POST PARKING LIFT

Maybe you don't have room to expand your garage, or maybe you just have a lot of cars. Either way, this lift maximizes storage space.



□ TWO-POST LIFT

The most common kind of lift, its arms adjust to fit a wide range of vehicles. This type leaves the wheels hanging for chassis repairs.



☐ IN-GROUND LIFT

A built-in hoist offers the same functionality as a two-post lift without the structure of the posts. Installation is complicated, though, since the hydraulics are buried in the floor

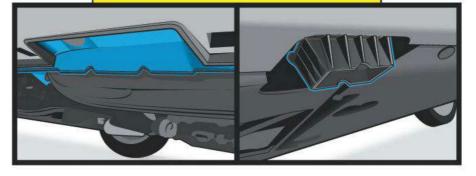


☐ FOUR-POST SERVICE LIFT

Four-post lifts offer ease of use and will accommodate almost any four-wheel vehicle, plus they can be mounted on less substantial floors.

TOOL TIP: JACK POINTS

Every car has specific jack points, places underneath where the structure is designed to accommodate a lift pad or a floor jack. They're typically located between the wheels and the lower sill. Look for notches (left) or footings (right). Otherwise, play it safe by reading the owner's manual.





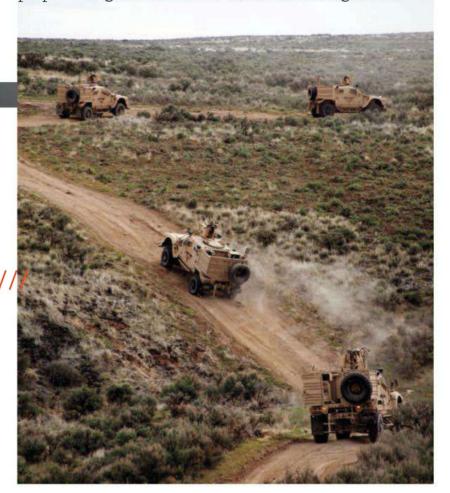
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New Turtle Wax® ICE® Liquid Wax does more than protect your car. Unlike conventional waxes, it repels dirt for a like-new brilliance that lasts. The enhanced resins and protective polymers in ICE Liquid Wax create the new hard-shell finish that keeps your car cleaner, longer. **turtlewax.com/ice**



Looking Downrange

You think you know special operations—teams of gunslingers who launch midnight raids against terrorist camps, blow up bridges, or call in covert airstrikes. But the traditional role of spec ops is training foreign soldiers and building stable nations, skills that will be put to the test as the U.S. withdraws from Afghanistan. PM rides with an A-Team as it prepares to guard America's exit from its longest war.



By Joe Pappalardo /

Photographs by Chad Hunt



120° 11' 29" W



DAWN IS BREAKING AS SIX MEMBERS OF the A-Team gather for physical training (PT) at an empty trailhead in Yakima, Wash. The men, dressed in MultiCam desert camouflage, deploy from a white government-issued van and immediately start unloading rucksacks and doing leg stretches.

Only half of the 12-man detachment, part of the 1st Special Forces Group, is available to stalk Rattlesnake Hills on the edge of the city for this morning's PT. One member is injured, another is in sniper training, and the team's Fox (intelligence specialist) is in dive school. The rest are sleeping off the prior night's guard duty at the Yakima Training Center. The clandestine operational detachment is a long way from its home base at Okinawa. The wide, undulating landscape and relentlessly rocky terrain here more closely resemble Afghanistan, where the team is slated to spend 2013.

The men shrug on 30-pound rucks and wordlessly start the brisk march. Boots crunch on gravel in an increasing cadence. The detachment's Alpha (commander) is a 29-year-old captain, a combat veteran who served in the infamously violent Korengal Valley in Afghanistan while with the conventional Army. His Zulu (senior nonenlisted) is a 37-year-old master sergeant; this team has no warrant officer, so the Zulu is second in command. Since this A-Team is readying for a deployment-they call it going downrange-their real names cannot be used. Special operations forces (SOF) value secrecy above everything except physical fitness.

The team's leaders call out a word of warning: No running allowed. "If one starts, they'll all try to be first," Alpha says. "We all have Type-A personalities on this team."

The trail winds steadily upward, past a handful of isolated ranch homes. As soon as the team sees an opportunity, the members leave the semipaved road and ascend a steep hillside matted with rocks and ankle-high tangles of scrub brush.

The team's senior Echo (communications specialist) pauses to admire the view. He's a sergeant first class with 15 years of experience in the military, including work as a scout and sniper in the conventional Army. His shoulders are broad and so is his grin. He smiles a lot. Yakima never looks better than it does from the crest of a hill at dawn, city lights still glittering under a recently risen sun. "Kinda makes getting up at oh-five-hundred worth it," he says.

A civilian four-wheel all-terrain vehicle is unexpectedly waiting for the team as it finishes zigzagging down the slope. The homeowner

SPECIAL OPS' GLOBAL SCOPE

YEMEN

DIRECT ACTION:

Airstrikes

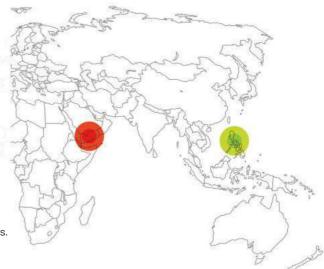
OBJECTIVE: Hunt members of al-Qaida in the Arabian Peninsula who are seizing towns and attacking government officials. **UPDATE:** Special Operations Command (SOCOM) and the CIA pick targets for drone and manned aircraft attacks against al-Qaida leadership and clusters of fighters. The website Long War Journal estimates that 23 strikes have been carried out since December 2009.

PHILIPPINES

INDIRECT ACTION:

Foreign Internal Defense

OBJECTIVE: SOCOM deployed to the island of Basilan to counter gains made by the Islamist insurgent group Abu Sayyaf. UPDATE: A 500-man spec ops task force trains local military units to take and hold around from Abu Sayyaf. Since the mission's inception in 2002, 17 U.S. service members have died while advising and assisting Filipino forces.





driving it quickly endorses the men's presence in a polite hearts-and-minds moment. "It's okay, if it's you guys," he says. "I have to come out and check on people, since methheads and hookers come up here to do their business sometimes."

It's considered a light morning of PT; a more typical start to the day consists of a 90-minute run (not including forward and backward sprints up the inclines and a slate of leg-burning squat thrusts) and the first of two daily free-weight workouts. But the next few days and nights at the Army training center will be crammed with lessons in operating vehicles they have never driven before. A brief hike will have to do.

Alpha's men will be among the nearly 10,000 special operators in Afghanistan in 2013, preparing for the administration's 2014 exit of major combat troops. "While the aggregate number of total personnel in Afghanistan will decrease as we approach 2014, the special operations forces' contribution may increase," Adm. William McRaven, head of Special Operations Command (SOCOM), told Congress in March. They will be there until at least 2017.

The expectation in Washington, D.C., is that these teams can take the lead in keeping the Afghan central government in control of a dysfunctional country of 35 million. If they can, America's longest war will end with a qualified win. If they fail, the nation could slip into civil strife and again become a haven for terrorists. "The rumbling around town is that special operations forces will basically own the U.S. mission in Afghanistan," says Travis Sharp, a fellow at the Washington, D.C.-based Center for a New American Security. "SOF has been on the rise for a decade. Now we are going to see if they can hold and consolidate gains." He adds: "If I trust anyone to get the job done, it'd be SOF."

Although Pentagon planners are finishing this war with a geopolitical Hail Mary pass, at least they are relying on the right players. Special operations A-Teams are made of incredible individuals with an action hero's résumé of skills: para-jumping, foreign-language fluency, a professional athlete's physical conditioning, and familiarity with an entire catalog of

Spec Ops Gear:

OFFICIALS AT SPECIAL OPERATIONS COMMAND IDENTIFIED WEAPONS TECHNOLOGIES THAT THEY WOULD LIKE TO FIELD IN UPCOMING YEARS. THEIR WISH LIST SHEDS LIGHT ON THE MISSIONS THAT OPERATORS CONDUCT.

DIY AIRSTRIKES

There are times in an operator's career when close air support or heavy artillery is not available and a target must be eliminated from a distance. In 2011, SOCOM asked industry for a missile system capable of striking enemy personnel, moving vehicles, and light structures at a range of 9 miles. The system's total weight is to be 65 pounds—light enough for a team to carry in rucksacks.



vehicles and weapons. And then there are the specialties: construction and demolitions, communications, intelligence gathering, and battlefield medicine verging on internal surgery.

These dedicated, sincere men are setting out to tame a land of suicide bombing, systematic abuse of women, and legendary duplicity. They are high-value individuals deploying to a place

Most of this A-Team has conventional Army experience in Iraq or Afghanistan and has done spec ops counterinsurgency work in the Philippines and Iraq.



BETTER MASKING

suppressors for rifle barrels that can

hide infrared and thermal signatures

vision goggles. These devices need to

work despite the weapon's recoil and

changes in its barrel temperature.

when the weapons fire—rendering them invisible to opponents' night-

FOR RIFLE SHOTS

SOCOM is seeking integrated

NEW TOOLS FOR SNIPERS

Flatter trajectory rounds

.338-caliber, and .50-caliber sniper

rifles will not only make the weapons

more accurate but will enable them to

hit targets with more kinetic energy at

extreme ranges. Another request is

for a sniper rifle that can be broken

down into a clandestine package.

for 7.62-mm, .300 Win Mag

NONLETHAL GRENADES

of 40-mm low-velocity grenade that

can dispense liquid or gas into a

the individuals inside.

vehicle or vessel without harming

SOCOM requested industry

solicitations for a new kind

- A SPOTTER HIDDEN ON A HILL PAINT THE TARGET WITH A LASER.
- NINE MILES AWAY, THE TEAM FIRES
- GPS COORDINATES GUIDE THE MISSILE
- THE SPOTTER'S LASER GUIDES THE MISSILE ON ITS FINAL, OR TERMINA STAGE FOR A DIRECT HIT

9 MILES

where human life has little value.

During the ruck march, I remark to Zulu that my backpack weighs about 20 pounds less than his. I recycle a line from a *Dirty Harry* movie to explain my minimalist packing: "A man's got to know his limitations." The 37-year-old Zulu shoots me a skeptical look. "Oh, really?" he says. It's clear I have spoken heresy. Admitting something can't be done is not in these guys' DNA.

THE SOFT SIDE OF SPECIAL OPS

When most people think of special operations, they think of lightning-fast raids that target terrorist leaders. The killing of Osama bin Laden was the capstone on a decade of aggressive wartime missions that the military calls directaction, or kinetic, missions. Although presidents have virtually no control over the planning or execution of these missions, they can be elected or booted from office based on their outcomes. Just ask Jimmy Carter, who signed off

MIGUEL

ВY

ILLUSTRATION

on an ill-fated hostage rescue in Iran.

Direct action, with its associated stealthy recon, building breaches, helicopter repelling, and double-tap gunshots—fits a violent stereotype of spec ops that does not match the reality. SOCOM has another mandate: to prepare other nations to take care of themselves. "The selection process is very good at weeding out anyone who only wants to shoot people in the face," Alpha says. "We need warrior-politicians."

These "indirect-action" missions include training foreign troops and teaching locals how to establish responsible governments. The strategy also promotes economic development by building bazaars, encouraging farmers to grow extra food crops to sell, and constructing roads. No one makes video games based on indirect-action missions.

The public may not have a good grasp on SOCOM's activities, but Washington, D.C., is increasingly relying on its broad mandate to counter global instability. Since 2001, SO-



SOCOM has become the U.S. government's tool of choice for soft power projection, but this is partly by default. "Most of our resources, when it comes to these types of efforts, are placed in the Department of Defense," says Rick Nelson, a senior fellow with the Center for Strategic and International Studies, who served with Joint Special Operations Command. "The reality is that the State Department and USAID are not funded at appropriate levels."

next decade and beyond," McRaven says.

Spec ops has become a tempting option for civilian policymakers. Teams are easy to send into the field because they can be deployed with little disclosure to the public or to regional allies, minimal advance warning, and fewer bureaucratic approvals. "The U.S. government is at risk of seeing SOF as a panacea for all of America's security problems in the world," Travis Sharp says. "There is a reasonable limit to what they can accomplish and remain sustainable."

The nation-building aspect of SOCOM's work is increasing as the war efforts recede and kill/capture raids become rarer. But those who assist SOCOM-Congress, which pays, and conventional forces, who contribute airlift, bases, and support personnel-may not be eager to aid the kinder, gentler SOCOM missions.

"The spotlight has been on the kinetic operations against high-value targets," says Adm. Eric Olson, former head of SOCOM. "Everybody lines up to support those, with a full capability and budgets." His concern is that as SOF leave battlefields, the smaller, less violent operations won't get the attention they need: "Instead of having the spotlight on special operations forces shift, I think it will just dim."

ECHO ON WHEELS

The senior Echo is behind the wheel of a \$470,000 mine-resistant all-terrain vehicle. wearing his helmet, communications headset, and trademark grin. He's never driven an M-ATV without an instructor before today, but there's no hesitation as he maneuvers the 32,000-pound behemoth across a mat of scrub brush at the Yakima Training Center. "Real men drive big trucks," he says over the rumble of the idling 370-hp engine. "As long as they're diesel."

The M-ATV is fun to take off-roading, but spec ops guys don't like them because they are loud and intimidating. Riding into a village in such a vehicle violates some of the core tenets LATIN AMERICA

INDIRECT ACTION: Foreign Internal

Defense **OBJECTIVE:** Promote military relationships with an annual competition, Fuerzas Comando.

UPDATE: Commandos from 19 countries participated in the 2011 competition. Events included a timed 11-mile forced march, sniper contests, and a combined airborne operation. U.S. troops placed sixth; El Salvador took first place

TRANS-SAHARA

INDIRECT ACTION: Civil-Military Support Element

OBJECTIVE: CMSE teams advise local governments on how to meet the needs of at-risk populations. **UPDATE: CMSE** teams from the 91st Civil Affairs battalion provide veterinary services, construction, and partnerships with reliable business leaders. This work is expanding; SOF Civil Affairs quietly added a fifth battalion in 2012.

LOOKING DOWNRANGE

120° 11' 29" W

POPULARMECHANICS.COM

2012 JULY

of the team's mission: Use what the locals have; project confidence; stay alert and maneuverable; relate on a human-to-human basis. "On a mission," Alpha says, "I'd just as soon walk."

But this is special operations, and the M-ATV has been modified to meet SOCOM's demands. The windshield is wider, and there is a hatch in the back to allow a crew member (dubbed a trunk monkey) to man a mounted weapon. These M-ATVs also have a common remotely operated weapon station (CROWS) affixed to the roof. With it, a gunner in the back seat can scan the surroundings with the system's day/night optics and use a joystick to fire the machine gun at whatever's in the onscreen crosshairs.

The team uses two M-ATVs to practice an offroad advance called a bounding overwatch. One truck remains still, scanning for threats with the CROWS, as the second rolls through the scrub brush. When the M-ATV in motion finds a place with a good view, it stops, and the first





NS



Ref. Code

SO YOU WANT TO BUY AN . . .

ULTRA-BOOK

hen Apple launched the wafer-thin MacBook Air in 2008, it seemed like an expensive, underpowered novelty. Now, superlight computers have hit performance parity with traditional laptops and prices have plummeted, with the rest of the PC industry hopping on the ultrabook bandwagon. What do you need to know before you buy? Let's look inside.

1 Screen The monitor determines the size and weight of the computer. To keep ultrabooks slim, manufacturers typically laminate LCD screens in place without a glossy protective top layer.

2 Battery Open an ultrabook and you'll see that half the real estate is occupied by a battery. These PCs can run 5 to 7 hours on a chargeaccept nothing less.

(1)

DIAGRAMS BY LANA BRAGINA

Anthony Verducci

by Glenn Derene and

This well organized mess of electronic parts used to be a beautiful Samsung Series 9 [\$1400].



Know what you want

11" \$1000 13" \$700-\$1300 14"+ \$600-\$1500 2 lb 3 lb 4 lb 5 lb

3 Unibody

chassis When you build something this thin, rigidity becomes an issue. Look for a firm metal (aluminum or magnesium) structure. Avoid plastic chassis, which can bend or break.

4 Ports Prepare to make do with fewer of these. Ultrabooks have no optical drive and rarely more than two USBs (make sure at least one is USB 3.0), plus an SD card reader. At the 11-inch size, you often lose the SD, too. 5 Wi-Fi Unless you want to carry around a USB or proprietary Ethernet dongle, the built-in

6 CPU The ultrabook's secret

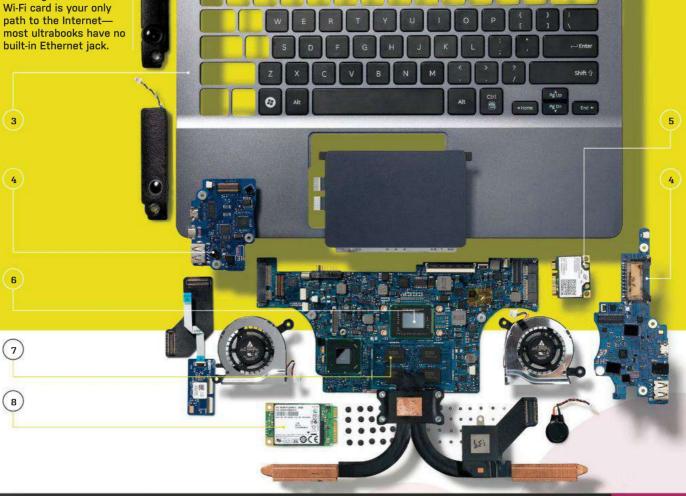
7 RAM In a typical computer, RAM is the most user-upgradable part. Not in ultrabooks. The RAM is soldered to the motherboard, so plan for the future by buying a machine with at least 4 GB.

8 Hard Drive Most ultrabooks use solid-state drives (SSDs) in the new mSATA format-essentially, that's a small circuit board with flash memory on it. SSDs are speedy, but capacity is low.

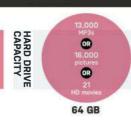
INSIDE THE PM LAB To take apart this ultrabook, we had to remove dozens of miniature screws. We counted 74 tiny 0.064-inch screws in the keyboard alone.

- ANTHONY VERDUCCI



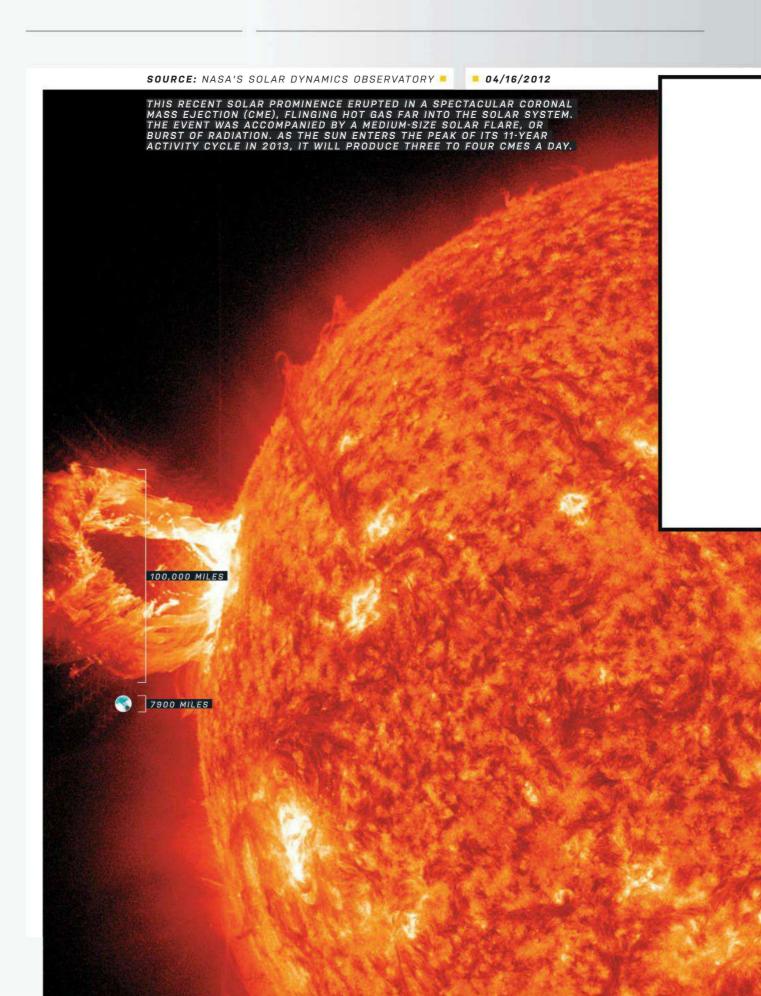








52,000 256 GB



Welcome to the new solar

maximum

BY LEE BILLINGS

The sun has been hurling plasma at Earth for billions of years, but the next direct hit could damage power grids and other infrastructureimmobilizing the technology that underpins civilization.



FOR MORE THAN a week, NASA officials cautiously watched as vast plumes of material, tens of millions of degrees Fahrenheit, arced from the far side of the sun. Then the culprit spun into view: a region of sunspots more than 13 times the diameter of Earth, bubbling with volatile magnetic fields. Around 7 am Eastern time, the region erupted, releasing a pulse of hot, electrified gas that shot toward the planet at millions of miles an hour. It was Oct. 28, 2003, and in the Service Module of the International Space Station, astronaut Michael Foale and cosmonaut Alexander Kaleri had just downed coffee as they prepared for the first full workweek of their 195day mission. The station's orbit was

sweeping the craft toward the South Atlantic Anomaly, an area above the eastern coast of South America where high-energy particles from the sun become concentrated.

Mission control called, Foale remembers. "They said, 'Hey, we've got some big events coming. We recommend you shelter in your crew station, Mike." With the radiation units on his personal dosimeter ticking upward, Foale floated 200 feet down two long tunnels to his sleeping quarters near the front of the station. He closed himself in the coffin-like room, lined with thick polyethylene foam bricks to shield his body from the protons flying through the stationthe product of one of the most powerful solar flares ever recorded. Outside, the craft glided through a curtain of brilliant green light-an aurora, created by electrons colliding with oxygen in Earth's atmosphere. "It was very dramatic and quite spectacular," Foale says. But to be enveloped in that energy is unsettling. "Obviously you think, this is not good," he says.

At 7:30 am, a satellite stationed between the sun and Earth observed the star gain an ominous halo, the telltale sign of a coronal mass ejection (CME). The billion-ton belch of magnetized plasma reached the planet the following morning. It slammed into Earth's magnetic field, which vibrated like a bell, and in a manner analogous to a moving bar magnet raising currents in a coil of wire, the CME sent powerful electric currents coursing through the planet. Those ground currents flowed into power lines; electric grids around the world strained. In North America, utility companies scaled back generation. In Sweden, a high-voltage transformer blew, blacking out the city of Malmö for almost an hour. The barrage of solar particles continued for days, interfering with satellites and radio communications; auroral lights danced across the sky as close to the equator as Florida and Australia. Roughly a week later, the sun's most active regions rotated out of alignment with

the planet. No lives were lost, but the storm had caused many hundreds of millions of dollars in damage.

The sun's activity roughly follows an 11-year cycle, and severe space weather tends to cluster around each cycle's peak. The sun is now entering the peak of Cycle 24, as evidenced by powerful solar storms it unleashed in January and March of this year. Those storms had little effect on Earth, largely due to chance: The orientation of the planet's magnetic field caused much of the radiation to slide over it. The next big CME will test that luck.

This deeply worries John Kappenman, founder of Storm Analysis Consultants and an expert on the effects of geomagnetic storms. His detailed investigations of the so-called Halloween Storm of 2003 found that it, too, had been dampened by the alignment of Earth's magnetic field. And yet it still blacked out an entire city and stressed continental power grids. If the planet had absorbed the full brunt of the CME, the blackout could have had far more severe repercussions. "If you lose electricity, within a matter of days you essentially lose almost everything else," Kappenman says. "After the initial blackout, we wouldn't really understand the seriousness of the situation until several days went by without having things restored. We'd rapidly lose the ability to provide the necessities for modern society."



THIS MAY SEEM like doomsaying, but the historic record suggests otherwise:

The Halloween Storm, in fact, appears minor compared with several earlier events. In March 1989, a geomagnetic storm knocked out a high-voltage transformer at a hydroelectric power plant in Quebec, plunging the province into a 9-hour blackout on an icy winter night. A storm that enveloped Earth in May 1921 sparked fires in telegraph offices, telephone stations, and railroad routing terminals connected to nascent power grids. The most extreme observed storm of all, called the Carrington Event, occurred in

"The physics of the sun and of Earth's magnetic field have not fundamentally changed, but we have. We decided to build power grids, and we've progressively made them more vulnerable as we've connected them to every aspect of lives." our

John Kappenman, Storm Analysis Consultants

September 1859: It caused geomagnetic currents so strong that for days telegraph operators could disconnect their equipment from battery power and send messages solely via the "auroral current" induced in their transmission lines.

"The physics of the sun and of Earth's magnetic field have not fundamentally changed, but we have," Kappenman says. "We decided to build power grids, and we've progressively made them more vulnerable as we've connected them to every aspect of our lives. Another Carrington Event is going to occur someday." But unlike in 1859, when the telegraph network was the sole technology threatened by space weather, or in 1921, when electrification was in its infancy, today's at-risk systems are legion.

Over the past 50 years, global power-grid infrastructure has expanded tenfold. Meanwhile, utilities have shifted to higher operating

voltages, which increase the efficiency of electricity transmission but make equipment less resistant to unregulated ground currents. As the grid has grown, so too has the practice of importing and exporting electricity between regions and even countries: A streetlight in upstate New York may be powered by a hydroelectric plant in Quebec; a neon sign outside a Tijuana nightclub may glow because of a naturalgas plant in Southern California. This interdependency increases the risk of widespread collapse. Humans have effectively created

continent-size antennae-all exquisitely tuned to soak up currents caused by space weather.

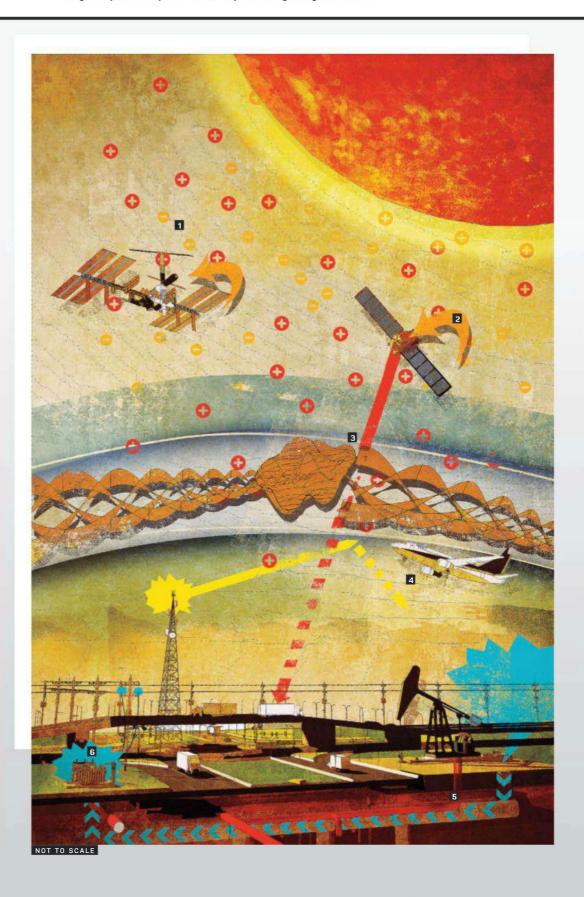
Over the years, Kappenman has undertaken a series of studies underwritten by various branches of the federal government. He has consistently found that a great geomagnetic storm, striking with little forewarning, would overheat hundreds or thousands of high-voltage transformers in the U.S. grid, melting crucial components and effectively crippling generation capacity. Building replacement transformers at current production rates would take up to 10 years, during which time more than 100 million people would be without centrally provided power. This would cost the economy an estimated \$1 trillion to \$2 trillion in the first year alone.

Last year the Department of Homeland Security asked an independent group of elite scientists, the JASON Defense Advisory Panel, to analyze Kappenman's claims. In its November 2011 report, the panel expressed skepticism that his worstcase scenario could occur but agreed that the U.S. power grid could suffer severe damage from a geomagnetic storm. The scientists called for more



During a coronal mass ejection, the sun violently blasts high-energy particles traveling several million miles an hour into space. When these particles sweep into Earth's magnetosphere a day or so later, they set off a geomagnetic storm.

- 1 High-energy protons and electrons pass through spacecraft such as the International Space Station, damaging electronics and degrading solar arrays.
- 2 They also heat and expand the upper atmosphere, which increases drag on satellites, reducing their lifetimes in orbit.
- Earth's ionosphere becomes distorted with radiation, and plasma bubbles form. GPS signals scintillate, or break up, as they pass through this region, disrupting the triangulation of points necessary for precise navigation.
- 4 Ionized particles also affect the propagation of radio waves. Airplanes flying above 85 degrees latitude rely exclusively on high-frequency radio communications, and so may be rerouted.
- 5 Vibrations in Earth's magnetic field induce strong electric currents in the ground. These follow the path of least resistance into oil and gas pipelines, causing corrosion.
- They also flow into power-grid infrastructure such as transformers, which can blow out from the sudden burst of unregulated current.



Sun Spotters

A handful of satellites keep instruments trained on solar activity, detecting radiation storms hurtling toward Earth. Half could fail at any time. — Dalene Rovenstine

Solar and Heliospheric Observatory (SOHO) Planned Mission Length: 2 years Launch: Dec. 2, 1995

SOHO uses its extreme ultraviolet imaging telescope to generate high-resolution images of the sun's corona and predict space weather in real time. NASA lost connection with SOHO for six weeks in 1998: the satellite now operates without a gyroscope for maintainng orientation

Advanced Composition Explorer (ACE) **Planned Mission** Length: 5 years Launch: Aug. 25, 1997

The satellite is equipped with six high-resolution spectrometers and three instruments that study solar wind and high-energy particles accelerated by the sun. After 15 years in space, ACE can still provide about an hour's advance warning of geomagnetic

Relations Observatory (STEREO) **Planned Mission** Length: 2 years Launch: Oct. 26, 2006

The two satellites in the STEREO mission study coronal mass ejections, leading to more accurate alerts for solar flares. The crafts reached a major milestone on Feb. 6, 2011: achieving 180-degree separation, which allowed a 360-degree view of the sun for the first time ever

Solar Terrestrial

Solar Dynamics Observatory (SDO) Planned Mission Length: 5 years Launch: Feb. 11, 2010

SDO's suite of instruments provides insight into how the sun's magnetic field is generated, structured, and converted into violent solar events-at near-IMAXquality resolution

Geostationary Operational **Environmental** Satellites (GOES) Planned Mission Length: 10 year GOES-13 Launch: GOES-14 Launch: GOES-15 Launch: March 4, 2010

Besides keeping a steady eye on Earth, GOES-15 equipped with a solar X-ray imager, a solar X-ray sensor, and an extreme ultraviolet sensor-helps NOAA forecast space weather too. GOES-13 backs up 15 during eclipses; however, its X-ray sensor is not reliable GOES-14 is orbiting in storage mode until needed

NOT TO SCALE

space-weather safeguards, including hardening electrical infrastructure and bolstering the nation's aging network of sun-observing satellites.

Physicist Avi Schnurr, who presides over the nongovernmental Electric Infrastructure Security Council, is among those doubtful that modern society will successfully address the problem. "If a Carrington Event happened right now it probably wouldn't be a wake-up alarm-it would be a good-night call," he says. "This is a case where we have to do something that is not often successfully achieved by governments, and certainly not by democracies: We have to take concerted action against a predicted threatening event without having actually experienced the event itself in modern times."

Protecting the grid is, in principle, relatively straightforward. Most high-voltage transformers connect directly to the ground to neutralize power surges from lightning strikes and other transient phenomena-but that also allows geomagnetic currents to flow upward. Experts estimate that electrical resistors or capacitors, which would sever that connection, could be installed at critical locations (such as near power plants or major cities) within a few years. In practice, however, it's not so easy: U.S. power companies have balked at voluntary installation of such devices, which could cost about \$100,000 per transformer.

Peter Pry, a former Central Intelligence Agency official and staff member on the U.S. House Armed Services Committee, has tried to spur legislative action on the threat of space weather. He has also watched in frustration as bills mandating protection of the grid repeatedly went nowhere. "The real danger here isn't astrophysical, it's institutional," he says. "The threat to everyone belongs to no one."





POWER OUTAGES wouldn't be the only cause of cascad-

ing failures in the event of extreme space weather. Jane Lubchenco, head of the National Oceanic and Atmospheric Administration (NOAA), points out that highly charged particles can also degrade the precision of GPS satellites. Signals from these networks allow receivers to calculate geospatial positioning and measure time to billionths-of-a-second accuracy. Besides providing directions for road trips, they synchronize cellphone conversations, orchestrate air traffic, and guide fleets of emergency vehicles.

"Today, most financial transactions are date-stamped with GPS, and GPS guides the dynamic positioning of most deep-ocean oil and gas operations," Lubchenco says. "Can you imagine the financial disruption that a GPS outage would cause? Can you imagine the Deepwater Horizons that would occur if drilling platforms

received erroneous GPS information?"

For now, the only way to ensure that power grids and satellite networks withstand another Carrington Event would be to preemptively shut them down when a big storm is likely to occur. "That's really not a good solution," Kappenman says. For one thing, each self-enforced outage would cost billions of dollars in lost productivity. For another, he says, "forecast systems probably aren't ever going to be precise enough to avoid false alarms."

Thomas Bogdan, former director of NOAA's Space Weather Prediction Center in Boulder, Colo., acknowledges "our ability to forecast is actually fairly poor." CMEs and solar flares will be particularly difficult to predict without better theoretical models of the circulation of plasma in the sun, but CMEs reliably occur three or four times a day during our star's activity peak, and approximately once a week during solar quiescence. "The only reason we really get by is that the sun has a regular activity cycle," Bogdan says.

The prediction center relies on constant surveillance of the sun for the slightest indication of a threatening event. Initially, this comes from ground-based observatories operated by the U.S. Air Force and a NOAA satellite network watching for the telltale X-ray pulses that signal solar flares. But only a few satellitesincluding the Solar and Heliospheric Observatory (SOHO) and the two Solar Terrestrial Relations Observatory (STEREO) spacecraft-can detect whether a radiation storm or CME is actually headed toward the planet. The Advanced Composition Explorer (ACE) can measure the intensity and magnetic orientation of any CME that sweeps by it. But 20 to 50 minutes later, forecasters can merely watch the storm unfold on Earth.

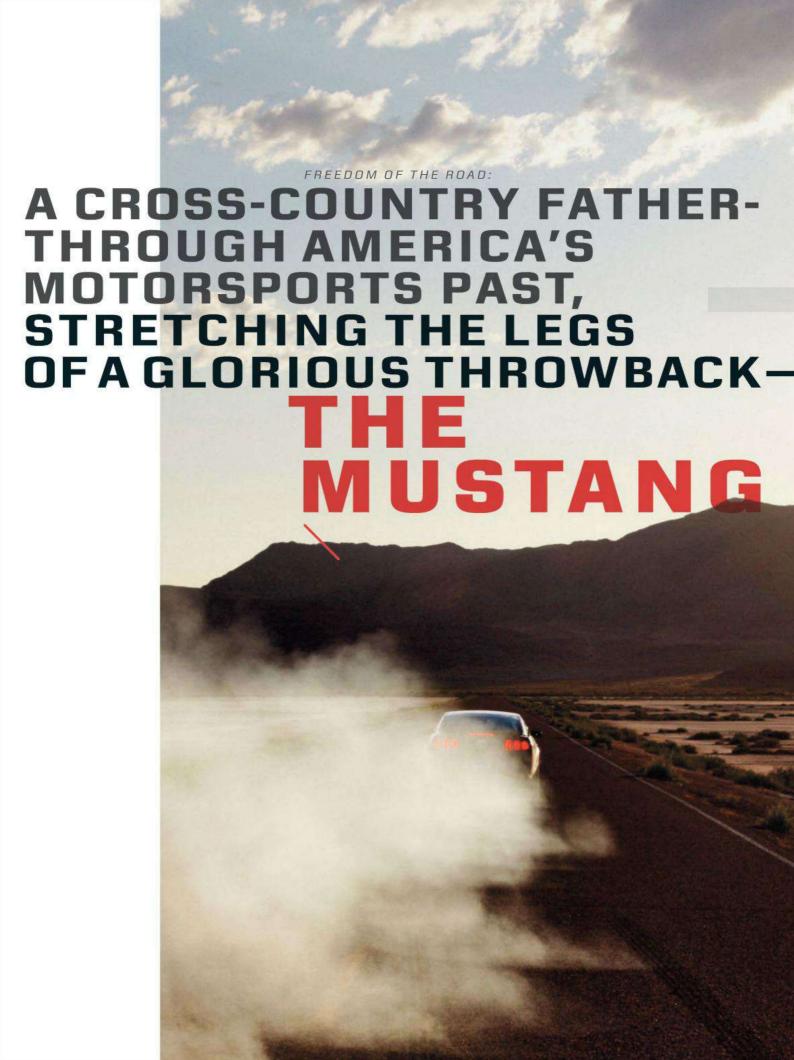
Disturbingly, both SOHO and ACE are well past their nominal lifetimes, with no certain replacements. "Once SOHO ceases functioning, probably in the next year or so, we won't have its unique 'looking down the barrel of a gun' perspective on the sun for forecasting Earth-directed CMEs," says

Sten Odenwald, an astrophysicist affiliated with NASA's Goddard Space Flight Center. ACE has sufficient propellant to continue operations until roughly 2024, but there are no guarantees its instruments will last that long. Without ACE, Odenwald says, "we'll [still] be able to see a CME coming toward us, but we won't know whether its interaction with Earth's magnetic field will cause major fireworks or be relatively harmless."

STEREO and another satellite, the Solar Dynamics Observatory, may be able to compensate for SOHO's eventual loss, but Lubchenco and other experts unanimously believe that allowing ACE's unique observational capabilities to expire would constitute a blind spot too large and risky to ignore. "Another great geomagnetic storm probably won't happen tomorrow, but that doesn't mean we shouldn't worry," Bogdan says. "The good news is, we've got time to prepare for this, but the bad news is, if we don't hedge our bets and buy down some risk, one day we're gonna get clobbered."

In fact, a spacecraft that could replace ACE currently sits in storage at Goddard's facility in Greenbelt, Md. The Deep Space Climate Observatory, or DSCOVR, is fully assembled and all but ready for launch-NASA simply lacked the funding to launch it into space seven years ago. As part of the Obama administration's budget request for 2012, NOAA would receive \$47.3 million to refurbish and launch DSCOVR to act as ACE's replacement, but the initiative died in the House.

After Foale rode a Soyuz TMA-3 capsule back to Earth in April 2004, he had blood drawn for an experiment that monitored his chromosomes. "Roughly, the rate of damage to my white blood cells went up by a factor of 10," he says. It dropped back down within the year. "Life has been dealing with radiation since it began," Foale says. "Repair mechanisms in the cells are very sophisticated." Human society, on the other hand, has evolved to be more fragilecomplex, yet defenseless against a storm of solar radiation. Meanwhile, the sun continues to seethe. PopMech



AND-SON JOURNEY

LIKE A LOT OF KIDS, I GREW UP AROUND OLD IRON. ALFA ROMEOS, MGS, THE ODD

BY SAM SMITH PHOTOGRAPHS BY THOMAS PRIOR

BOSS 302

Triumph-my father, Dan, an amateur racer, owned and drove more of them than I can count. But so did a lot of fathers.

My dad was different. When I was a boy, he set aside a midlevel marketing job of regular moves and little passion to follow his bliss: He wanted to start his own business. The first, an automotive bookstore, lasted only a few years. The second, a restoration shop that specialized in cantankerous European sports cars, existed in one form or another until I hit college.

That shop meant a lot to me. After school, I'd hang around my father's toolbox, watching him spin wrenches and solve problems. He had been teaching me to work on cars for years, but the shop was a stark cementing of principles. It made everything real.

I didn't think much of this-and didn't realize how important it was to me-until one night in the fall of 1998, when I was 17. Dad and I drove 10 hours from our home in Kentucky to Watkins Glen, N.Y.,

During a cross-country run in a Ford Mustang Boss that left little rubber on the tires, two petrolheads—the author and his father—gun the Boss's 444-hp V-8 and kick up a little Utah dust en route to the West Coast.

for the 50th anniversary of the first postwar American sports car race, held on the town's closed-off streets. Amateur drivers had flown around the town's houses at full tilt, with only hay bales and bunting separating them from packed spectators. It was the beginning of the country's modern speed era, a moment as significant as the inaugural Indianapolis 500 back in 1911. The area went on to host everything from IndyCars to Formula One-from Andretti to Zanardi.

The Glen's public road races are gone, victims of safety concerns, but the heart of that culture lives on at an Adirondack-style resort called Seneca Lodge, which sits on a hill overlooking town. The lodge hasn't changed much since 1948, and most people hope it never will, because it houses the most famous racing bar in America.

My father took me there on our first night at the lodge back in '98. A gentle and relatively quiet man, he didn't give me much warning that we were about to enter hallowed ground, a temple that has welcomed drivers since Truman was president. Instead, he just paused at the door and said, "This place is important."

The Seneca Lodge bar turned out to be no larger than a twocar garage, unprepossessing and poorly lit. Tattered photographs of dead drivers were pinned above the bar. Browned victory wreaths hung from darkly varnished walls.

But the place was filled with legends-heroes I had read about since I was a little boy. Formula One drivers and team managers sat in the corners, including 16-time Grand Prix winner Stirling Moss of Britain. American John Fitch, who won at Sebring and raced six times at Le Mans, was at a table with other winners who had too many checkered flags to their credit to count. There was pioneering American sports car driver and journalist Denise McCluggage. They were all in town for the anniversary, a living rogues' gallery from the stories of my youth. Dad and I stood there for a moment, soaking it all in, before he moved on



I pulled into a Walmart.
"I forgot," I said. "I need to
buy a cheap wrench."
"What for?" Dad asked.
"For America," I said.

to greet a few friends.

In that moment, I knew . . . well, I wasn't sure what I knew. But something clicked. A part of my life began to make sense.

In the years since, Dad and I have raced together and fixed cars together, and last summer we again walked through the door of the Seneca Lodge bar. The night wasn't as celebratory for the patrons there, but we were both thrilled, and not just to be back. We were about to fulfill a dream-a crosscountry journey together to trace the history of American road racing, something we had wanted to do for years. Naturally, we started at the Glen. And for reasons both patriotic and reverent, we decided to make the trip in a 2012 Ford Mustang Boss 302.

The V-8-powered Boss is no ordinary Mustang. This is a rolling homage to the Boss 302s that contested the Sports Car Club of America's Trans-American (aka Trans-Am) racing championship from 1969 to 1970. It's a snarly collection of historical cues (C-shaped side stripes, rocker-mounted sidepipe exhausts) and legitimate performance cred (adjustable dampers, limited-slip differential, Brembo brakes, optional Recaro seats). In terms of emotional appeal and over-the-road talent, it might be the greatest ponycar ever built.

The idea was to drive the Boss from Watkins Glen to California's Mazda Raceway Laguna Seca in Monterey. Along the way, we'd stop at a vintage race at Wisconsin's Road America, test the Ford's talents at a track day, and just generally inhale a bunch of blacktop.

We spent most of the first night in the Seneca bar, which felt like a return to baptismal waters for me. The next morning, Dad pulled a



dog-eared copy of Dave Friedman's Trans-Am: The Pony Car Wars 1966-1972 from his luggage. The book is packed with hero drivers and pictures of Mustangs being shotgunned around places like Laguna, which hosted the final race of Ford's championship-winning 1970 Trans-Am season. This is where I learned that my father, a lifelong European-sports-car nut, has always had a soft spot for big V-8s. While loading the car, I walked out into the parking lot and found him staring at the Boss, arms crossed, giggling. My dad doesn't giggle. Memo to Ford: Whatever you're doing here, keep it up.

We gunned out of the Seneca at 9 am, sun glinting off the Boss's long nose. Fifteen minutes later, remembering a recent conversation with a Ford engineer, I pulled into a Walmart. "I forgot," I said. "I need to buy a cheap wrench."

LEGENDARY AMERICAN TRACKS



WATKINS GLEN INTERNATIONAL WATKINS GLEN, N.Y.

A fast, sweeping 2.4-mile circuit that overlooks Seneca Lake. Designed by a cadre of Cornell engineering professors to replicate the original street course.

SIGNATURE TURN: THE CLIMBING ESSES

Taken at full throttle, these switchbacks are critical to get right since they lead onto the long back straight where most of the passing occurs.

ROAD AMERICA PLYMOUTH, WIS.

Rewards flat-out courage because many turns require only minimal braking. Even low-powered Miatas average 80 mph around the 4 miles.

SIGNATURE TURN: THE KINK

A gentle right-hander negotiated at over 100 mph. Run wide and you'll smack a very nearby concrete barrier. Only the brave-or foolishkeep the throttle floored. Makes even pro drivers nervous.

MAZDA RACEWAY LAGUNA SECA

MONTEREY, CALIF.

Snakes around and over a peak that's only a few miles from the Pacific. Intimidating and thrilling, with dramatic elevation changes and a rhythm that would be genius if it weren't accidental.

SIGNATURE TURN: THE CORKSCREW

A left-right combination that steeply plunges downhill. Drivers can't see the entire track surface, so they rely on memory to stay online.

"What for?" Dad asked.

"For America," I said.

Crawling underneath the Mustang in the parking lot—we used a parking curb as a jacking ramp—I loosened the exhaust brackets and pulled the factory-installed noise-abatement plates out of the side pipes, transforming the Boss's 5.0-liter V-8 from a subtle rumbler to a rolling peace disturbance. "This is great," I said, blasting up an on-ramp. "You think we'll get tired of it?"

"I can't hear you!" Dad yelled.
"Can we make it louder?"

It soon became apparent that the Boss, like most Mustangs, is happiest just above the speed limit. The car eased into a long-legged lope that implied California was just over the horizon. Pennsylvania and Ohio flew by, the newly opened side pipes crackling every time we stopped for fuel.

What is it about loud cars that reminds you of aircraft in wartime? Eighty-five mph in sixth gear produced a steady, comforting, dawnpatrol drone. Full-throttle gear drops made my skin tingle and prompted furtive glances toward the horizon. (Fighters! Twelve o'clock!) At one point, with the Mustang exploding through the top of third gear, I heard Dad mutter, "Combat emergency power." When I looked over, he was squinting into the distance like Chuck Yeager.

With I-80 being both long and boring, we had a lot of time to talk. Dad told me stories of his Kentucky youth—how he crashed his MG Midget twice in high school, the big Detroit sleds his father drove, the moment he first felt drawn to muscle cars. At one point he paused and said, "I've always wanted a Mustang, but until now, it's never felt right. This car has been seeping into my head for 40 years."

We passed a school bus near Cleveland. When half the kids lowered their windows to watch, I stabbed the throttle, prompting cheers. Mustangs have been seeping into America's head for a while.

We reached the tiny village of Elkhart Lake, Wis., at the end of the second day and headed for nearby Road America, a 4-milelong, European-style track built in the 1950s. When my head hit the pillow that night, the Ford's pipes still rumbled in my ears.

The Boss's 302-cube overheadcam V-8 is an evolution of the 412hp Coyote engine found in the Mustang GT. It produces 444 hp and revs to an astonishing 7500 rpm. The gains over a GT are courtesy of CNC-machined cylinder heads, a long-runner intake manifold, larger intake valves, higher-lift cams, and a host of other tweaks. Maximum torque (380 lb-ft) comes at a relatively high 4500 rpm, so the engine feels somewhat peaky. A baffled oil pan helps maintain oil pressure during cornering. The end result is a corker. The 302's idle is smoother than poured cream, but the engine revs like it has a flywheel made of dryer lint. It reminds you of the weapons-grade V-8 fitted to the 1969-70 Boss 302s. And that's why we went to Wisconsin.

A few weeks before, I learned that the Historic Trans-Am Group—vintage racers who regularly exercise 1960s Trans-Am cars—was going to be at Road America during

With one wrench it's easy to yank the 302's factory noise cancelers.

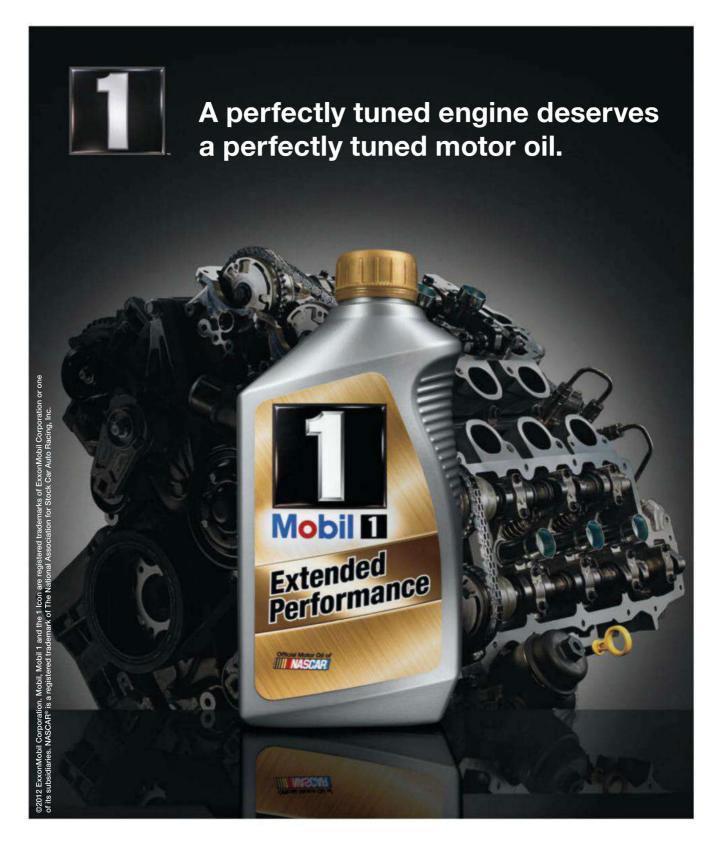
our trip. A detour suddenly became mandatory. Watkins Glen hosted Trans-Am races for years, but Road America's long, tree-lined straights, steep hills, and wincingly fast corners always felt more suited to it.

In the Trans-Am's golden era-1966 to 1972-the series featured production-based, factory-backed cars; star drivers; and competition so close that drivers often banged door handles. It's been called the most crowd-pleasing racing in American history, and as the vintage cars-some worth seven figures-were started for the coming race, it was easy to see why. As each lit off, the noise mutated from an offbeat thunderclap-BOOMawhompa-BOOMa-whompa-to a stunning cacophony. The drama was intoxicating.

We walked over to Turn Six, a third-gear left-hander, for the start. On the first lap the cars exploded into sight with a gut-punching din. Dad laughed involuntarily. The field slithered and pulsed through the corner, two and three deep, each car jockeying for position in a series of feints and dodges.

The field spread out as the race went on until the sound seemingly came from everywhere. Several original Boss 302s—including the championship-winning yellow 1970 car driven by Parnelli Jones





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and George Follmer—worked their way to the front of the pack. When the checker fell, I had no idea who won, and I didn't really care. I just wanted more.

Earlier that day we had met former Shelby Cobra racer Phil Gallant, who owns the first Boss 302 Trans-Am racer, a blue 1969 model that was built by Michigan's legendary Kar Kraft shop, prepared by Carroll Shelby, and driven by American ace Dan Gurney. "These cars are heavy, so they react slower than a Cobra," Gallant said. "They are a lot more dramatic—you drive sideways."

Walking back through the paddock, I ran into Jim Farley, Ford's vice president of global marketing, who was there to race his Cobra. Farley, who helped usher the 2012 Boss to production, once said it deserved to be on YouTube "doing something illegal." He told us about the car's development and mentioned that he had just been doing laps in his own Boss at GingerMan Raceway in South Haven, Mich., to see what it could do. GingerMan is roughly 2 hours northeast of Chicago. Twenty-four hours later we were rolling into the track's parking lot.

Caning the Ford around GingerMan's 2.14 miles was a revelation—the Boss has to be one of the most balanced street cars on the planet. Feed this car late apexes and gobs of throttle, and a blindfolded donkey could set lap records.

Dad did a few sideways laps and giggled again. When we grabbed a motel room that evening, he spent most of the night reading Brock Yates's Sunday Driver, a firsthand account of a novice's first season in the Trans-Am. I stared at the "Build Your Own" Mustang section of Ford's website, smitten.

The rest of the Midwest passed in a haze of midsummer heat. By the time we hit Nebraska, I had called in a few favors and found a Ford dealer who might sell me a Boss at sticker price. By Utah, I knew the color I wanted (Competition Orange) and which options (Recaros, Torsen limited slip).

Talking about the Boss even got my father and me out of a few arguments—our relationship has never been perfect, but the Mustang smoothed out the bumps. The car, like Seneca Lodge, meant something to us that we couldn't nail down, something that obviously chimed with a lot of other people too. (I've never been on a trip where so many men asked what I was driving.)

A day later we rolled into Laguna Seca, thoroughly exhausted. A MotoGP race—Formula One for motorcycles—was carving up the track, so we left the dusty Ford in a parking lot and bought tickets. Laguna looks just as it did in Friedman's book, albeit with modern, clinical catch fencing and lots of runoff area. Compared with the raw streets of the Glen, it was a cold testament to progress. But mostly, it made me hanker for more sideways Trans-Am cars. Or a Boss of my own.

About that: Two days earlier, at a truck stop in Grand Island, Neb., I stumbled onto a bin of Hot Wheels cars. Dad dug in and pulled out a Mustang. It was a 1970 Boss race car, complete with Parnelli Jones's name on the roof. I bought it and rolled out of Grand Island feeling like I'd just won the lottery.

After returning the 2012 Boss to Ford, I flew home to Chicago and discussed the Mustang with my wife. She informed me that we couldn't sell the couch and the refrigerator and most of my clothing to buy one. But a month later, Dad texted me a picture of a Kona Blue 2012 Boss 302 on temporary tags parked in his driveway. He had found one at his hometown Ford dealer one afternoon and bought it. Just like that.

I walked into my garage, moved my wife's car out, and set the Hot Wheels Boss on the ground in its place. I stared at it for a few minutes, and then walked back into the house. **PopMech**

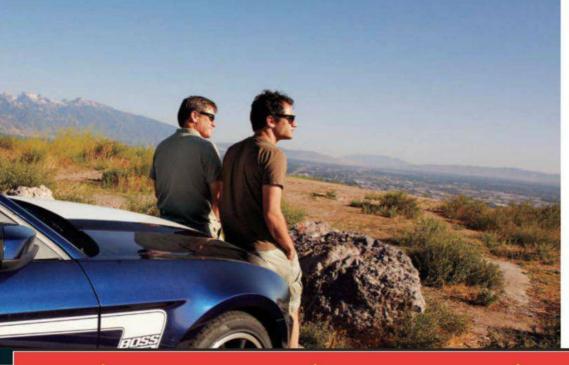


HOW TO PREP AND MOD YOUR CAR FOR THE

TRACK

It's never been easier to test your car—and yourself—on a racetrack. Several circuits offer "test and tune" lapping sessions where a small entry fee gives you access to a speed-limit-free asphalt ribbon. The Sports Car Club of America and the National Auto Sport Association regularly host track days for novices. Of course, your steed will need some attention. Get addicted—trust us, it isn't hard—and you'll find yourself modifying your car for greater control and speed. Car racing, however, is filled with axioms like "How do you make a small fortune in racing?" The answer: Start with a large one. You've been warned.

BY LARRY WEBSTER



The author [right], his dad and the Bossin the American west.

THE BASICS

INCREASING PERFORMANCE

DEDICATED TRACK MACHINE







ENGINE

Make sure the motor is up to snuff by inspecting the coolant hoses (they should be flexible). Change the oil and top up all the fluids.

SUSPENSION

Inspect for leaking shocks or torn axle boots. Weaknesses here will show up at the worst possible time.

BRAKES

For your first track visit, just make sure everything is in good working order. For the second, change the fluid to higher temp stuff like AP600.

TIRES

RIGHT

STUFF

Tire flex is an issue, so add 5 to 10 psi (cold) and keep an eye on tread wear.

PROTECTION/ RECOVERY

Snell 2005 rating or better since it's accepted by most organizers. And don't forget eye protection.

A helmet is a must. Buy one with a

Piloti Prototipo shoes (\$85) have curved heels that make operating the pedals easier.

A computer reflash can unleash more power from turbo engines but voids the warranty. For the rest, consider freer-flowing air filters and exhausts.

Stiffer antiroll bars can increase handling precision. Adjustable bars are even better; they let you dial out understeer.

Track driving fries brakes. Switch the pads to ones with higher temperature capability, such as the Hawk HP Plus. These pads consistently slow the car, even after repeated laps.

Swap all-season tires for performance meats. Look for tread-wear ratings of around 140 to get a good mix of street durability and racetrack grip.

Eventually, you'll make a mistake, slide off the pavement, and become beached in a gravel trap. Install factory tow hooks before you hit the track to ease recovery.

By now, you've got racetrack fever. Car modifications won't increase speed nearly as effectively as better driving. Skip Barber high-performance driving courses (\$1300 and up) are run throughout the country.

Aftermarket supercharger and turbocharger kits are the bang-foryour-buck kings. Beware: Extra spice stresses the drivetrain.

Lower the car with shorter springs. Preexisting suspension kits are usually preferred because the manufacturer has (we hope) figured out hard-to-determine details—like spring rates.

Faster cars require larger—both in thickness and diameter-brake rotors to dissipate heat. You might also need larger wheels to fit the new binders.

"Slick" tires have no tread and are like driving on marbles when it rains. But, designed for racing, they put more rubber on the road—increasing cornering speeds and shortening braking zones.

Now you're hard on the gas—everywhere. Increase safety with a steel interior cage. Bolt-in units are available for around \$500, but custom-welded cages typically allow easier access.

Measuring the temperature across the tire's tread tells you if the setup is correct (generally, you want equal temps across the tread). Intercomp's digital pyrometer (\$189) does the job.







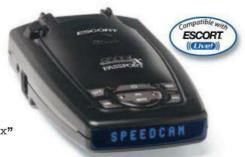
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building a boombox from scratch is child's play. p. 138

AUTO

't Be an Idiot

Why opening the radiator cap of your car's hot engine isn't such a hot idea. **p. 127**



Our experts tackle your toughest tech, home, and auto questions.

TESTED & RATED!



How much riding mower can you get for under \$2000? p. 110

Do you really need all that neatly clipped turf in your yard? ₹If the answer is yes, that's okay. But we've got options for a more relaxed and less labor-intensive landscape. p. 104

AUTO

Air tools-the staple of any serious car guy's garage-make tough jobs easy and impossible ones feasible. We show you how to get started with pneumatic power.

EXPERT TECH ADVICE



VIDEO-EDITING TIPS FROM AN INDUSTRY VETERAN. p. 135

The great firefly count is on! Do your part. It's fun and scientifically beneficial. p. 118







SCALING BACK

IS AN EXPANSIVE LAWN RIGHT FOR YOU? HERE'S HOW TO PICK A LANDSCAPE PLAN THAT SUITS YOUR STYLE AND BUDGET.



hether compelled by tradition, keeping up with the Joneses, or the joy of spending time outdoors, 69 percent of U.S. homeowners do their own yardwork, and maintain 40,000 square miles of lawn. Mowing, blowing, raking, weeding . . . the list of tasks is long-but it doesn't have to be. To illustrate the point, Julie Bargmann, a New

York-based landscape architect, sketched three versions of a typical 1/3-acre residential lot for Popular MECHANICS, from high- to low-maintenance. (Full disclosure: She's my sister.) "A lot of chemicals and water are used to get 'perfect' yards," Bargmann says. "But there are alternatives. It can be liberating to apply a less labor-intensive aesthetic to your personal outdoor space."

Other landscape experts we consulted share this sentiment. They say that reducing yardwork involves shrinking lawn size, increasing your plant palette, and using less water and chemicals. "A sustainable landscape can mean spending fewer hours on the yard," according to Judy Nauseef, a landscape designer from Iowa City, Iowa.

Here's a look at a few options. — JOE BARGMANN





- Who It's For Fastidious people with green thumbs, time to burn, a yen for outdoor entertaining, and what Jeff Trojanowski, a Los Angeles landscape architect, describes as a "formal, colonial" aesthetic.
- Pros Neighborhood bragging rights; privacy created by perimeter plantings and fence; a soothing sense that all is in order; plenty of space for lawn games when hosting the big July Fourth family barbecue.
- **Cons** Hassle of weekly yard-waste disposal (especially onerous after hedge trimming); high water bills; painful puncture wounds from rose-garden maintenance; obligation to host the big July Fourth family barbecue.



Tools Gas mower, hedge trimmer, string trimmer, blower, pruners, lots of hoses, sprinklers, pump sprayer, fertilizer spreader.

17
hours a week

\$2075 annual upkeep

8 hours a week

\$2545*
annual upkeep



NATIVE GRASSES & WILDFLOWERS



Who It's For Families with soccer mom/dad duties (thus, less time for yardwork) who like to be "green" and also want to get good use out of their outdoor space; couples who enjoy gardening but refuse to be slaves to it.

Pros Clippings pile/compost area for on-site yard-waste disposal; just enough lawn for fun but not too much to mow; softer edges and semiwild feel show that you care about appearances—but not to a fault.



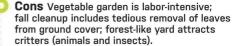
Cons While you'll be mowing less, you'll have to bone up on your other gardening skills, such as pruning, to maintain the flowering shrubs, perennials, and shrub borders. Resist the urge to call in a pro. C'mon, you can do it yourself!

Tools Cordless electric mower, string trimmer, and hedge trimmer; loppers, pruning shears, leaf rake, garden cart.



Who It's For Birkenstock-wearing college professors or nonprofit employees who practice sustainable living and are oblivious to their eccentricities—or embrace them and couldn't care less what the neighbors think.







Tools Electric blower and string trimmer, small mulcher, hand tools for gardening, loppers, pruning shears, rake, wheelbarrow.

*Includes high initial cost to establish ground cover.





OCHILLE

In architecture, the Latin word for "eye" describes circular windows, skylights, and other openings, such as the hole in the top of the dome of the Pantheon in Rome. Specific to 17th-century Baroque architecture, oculus and oeil-de-boeuf [French for "bull's-eye"] are used interchangeably.















PATRON

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1 Form and Cast

Screw together the inner and outer forms. Coat the exterior of the inner form with glue, and cover the surface with aluminum foil. Do the same for the inside face of the outer form. Spray cooking oil on the foil surfaces.

Place the inner form, top-down, on the mounting board. Screw through the bottom of the board into the form's cross supports. Place the outer form over the inner one, and use angle brackets to secure the outer form to the mounting board.

Empty an 80-pound bag of Ouikrete Countertop Mix into a wheelbarrow. Add about 5 ounces of buff liquid cement color to 1 gallon of water in a bucket. Add the tinted water to the powdered concrete a couple of cups at a time until the mixture is malleable but not runny.

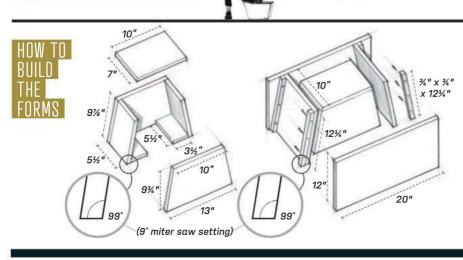
Pour the concrete into the form (left, top). Repeatedly plunge a scrapwood stick into the concrete to consolidate it. Overfill the form, then run an oscillating sander (without sandpaper) over the entire form to vibrate out voids. Strike off excess concrete. Form drain holes by pushing two dowels coated with petroleum jelly through the concrete.

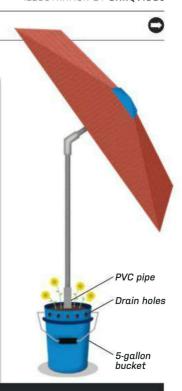


After letting the concrete set for 18 hours, unscrew and disassemble the outer form (left, center). Grab and twist out the dowels with pliers.

3 Pull the Inner Form

Remove the screws driven through the bottom of the mounting board and into the inner form. Tip the planter over and pull out the inner form (left, bottom). After the concrete has cured for 24 hours, apply a liberal coat of clear masonry sealer to the entire planter. Once the sealer cures, you're ready to plant!





THE RECYCLER

PATIO-UMBRELLA STAND

POPULAR MECHANICS READER TED ABT OF MORRISVILLE, PA., FOUND A GOOD USE FOR PVC PIPE AND A 5-GALLON PLASTIC BUCKET LEFT OVER FROM A REMODELING JOB.

How to Make It

Dump most of an 80-pound bag of concrete into the bucket, add water, and mix. Use duct tape to seal one end of a piece of 1½-inch PVC pipe, and push that end into the slurry. After the concrete sets, bore ¼-inch drain holes through the bucket. Top the concrete with a layer of gravel cov-ered with potting soil. Plant flowers, and insert a patio umbrella. Enjoy!



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DIY HOME

Riding Mowers

DECK [INCHES]: 46

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"America's love of tractors reaches back for generations and stands true today."

PRICE: \$1600

DECK [INCHES]: 46

HUSQVARNA YTH21K46

The Husqvarna is equally at home on wide-open lawns and in tight spots. A large lever by the steering wheel enables quick engagement and disengagement of the mower deck, and right-foot pedals allow for easy speed control and switching between forward and reverse. The pedals are especially helpful when your hands are full turning the steering wheel while mowing in close quarters. Dislikes: The Husqy

lacks a dash-mounted mechanical fuel gauge. ENGINE [HP]: 20

CUB CADET LTX 1045

> If your lot is small or has complex landscaping, requiring a lot of back-andforth mowing, the Cub is your machine. The hydrostatic-drive foot pedals to the driver's right are large, especially the reverse pedal. Similarly, its interlock for mowing in reverse is connected to the ignition switch, and its position is clearly marked and accompanied with a pushbutton. For those who have been baffled by other, less helpful reverse-mowing setups, this could be a real plus. Dislikes: Nothing noted.

The Deere is sure-footed going up and down hills, over roots, and around any obstacle. This is due to the foot-pedal hydrostatic drive and a PTO (power takeoff) lever by the steering wheel that makes it easy to work around rocks and other obstructions. A large lever on the left-hand side helped us swiftly lift the deck out of harm's way. Dislikes: These are minor complaints, but the plastic hood hinge, seat, and discharge chute are insubstantial and evidence of cost cutting.

JOHN DEERE D110

PRICE: \$1700 ENGINE [HP]: 21 DECK [INCHES]:

RANKING

PRICE: \$1740 ENGINE [HP]: 21 DECK [INCHES]: 46

RANKING

A large lever on the right rear fender shifts the tractor into forward or reverse. It's like cruise control, an ideal feature for mowing big areas. Fat rear tires-the 9-inch treads are 2 inches wider than those of the other three mowers—reduce tire marking. Dislikes: We liked the Craftsman better on wide-open areas than on the intricate parts of our test course because we found ourselves constantly taking our hands off the steering wheel to shift into forward or reverse.

CRAFTSMAN YT 3000

DEAL WITH IT! IT'S WHAT MEN DO.

YOU FACE THINGS HEAD ON, WHY WOULD THIS BE ANY DIFFERENT?

More than half of all men over 40 have some degree of erectile dysfunction (ED).*

If you're one of them, ask your doctor about VIAGRA. It's America's most prescribed ED treatment.

For more information go to viagra.com or call 1-888-484-2472 (1-888-4VIAGRA).

THIS IS THE AGE OF TAKING ACTION.

VIAGRA® (sildenafil citrate) tablets

WITH EVERY AGE COMES RESPONSIBILITY, IMPORTANT SAFETY INFORMATION BELOW.

We know that no medicine is for everyone. Don't take VIAGRA if you take nitrates, often prescribed for chest pain, as this may cause a sudden unsafe drop in blood pressure.

Talk with your doctor first. Make sure your heart is healthy enough to have sex. If you have chest pain, nausea, or other discomforts during sex, seek medical help right away.

In the rare event of an erection lasting more than four hours, seek immediate medical help to avoid long-term injury.

In rare instances, men who take PDE5 inhibitors (oral erectile dysfunction medicines, including VIAGRA) reported a sudden decrease or loss of vision, or sudden decrease or loss of hearing. It is not possible to determine whether these events are related directly to these medicines or to other factors. If you experience any of these symptoms, stop taking PDE5 inhibitors, including VIAGRA, and call a doctor right away.

The most common side effects of VIAGRA are headache, facial flushing, and upset stomach. Less common are bluish or blurred vision, or being sensitive to light. These may occur for a brief time.

VIAGRA does not protect against sexually transmitted diseases including HIV.

 $Please \, see \, Important \, Facts \, for \, VIAGRA \, on \, the \, following \, page \, or \, visit \, viagra. com \, for \, full \, prescribing \, information.$

*Data taken from the *Massachusetts Male Aging Study*. Of 1,290 respondents, 52% stated that they had some degree of ED.

You are encouraged to report negative side effects of prescription drugs to the FDA. Visit www.FDA.gov/medwatch or call 1-800-FDA-1088.



IMPORTANT FACTS



(vi-AG-rah)

IMPORTANT SAFETY INFORMATION ABOUT VIAGRA

Never take VIAGRA if you take any medicines with nitrates. This includes nitroglycerin. Your blood pressure could drop quickly. It could fall to an unsafe or life-threatening level.

ABOUT ERECTILE DYSFUNCTION (ED)

Erectile dysfunction means a man cannot get or keep an erection. Health problems, injury, or side effects of drugs may cause ED. The cause may not be known.

ABOUT VIAGRA

VIAGRA is used to treat ED in men. When you want to have sex, VIAGRA can help you get and keep an erection when you are sexually excited. You cannot get an erection just by taking the pill. Only your doctor can prescribe VIAGRA.

VIAGRA does not cure ED.

VIAGRA does not protect you or your partner from STDs (sexually transmitted diseases) or HIV. You will need to use a condom.

VIAGRA is not a hormone or an aphrodisiac.

WHO IS VIAGRA FOR?

Who should take VIAGRA?

Men who have ED and whose heart is healthy enough for sex.

Who should NOT take VIAGRA?

- · If you ever take medicines with nitrates:
 - Medicines that treat chest pain (angina), such as nitroglycerin or isosorbide mononitrate or dinitrate
- If you use some street drugs, such as "poppers" (amyl nitrate or nitrite)
- · If you are allergic to anything in the VIAGRA tablet

BEFORE YOU START VIAGRA

Tell your doctor if you have or ever had:

- · Heart attack, abnormal heartbeats, or stroke
- Heart problems, such as heart failure, chest pain, or aortic valve narrowing
- · Low or high blood pressure
- · Severe vision loss
- · An eye condition called retinitis pigmentosa
- · Kidney or liver problems
- · Blood problems, such as sickle cell anemia or leukemia
- A deformed penis, Peyronie's disease, or an erection that lasted more than 4 hours
- · Stomach ulcers or any kind of bleeding problems

Tell your doctor about all your medicines. Include over-the-counter medicines, vitamins, and herbal products. Tell your doctor if you take or use:

- Medicines called alpha-blockers to treat high blood pressure or prostate problems. Your blood pressure could suddenly get too low. You could get dizzy or faint. Your doctor may start you on a lower dose of VIAGRA.
- Medicines called protease inhibitors for HIV. Your doctor may prescribe a 25 mg dose. Your doctor may limit VIAGRA to 25 mg in a 48-hour period.
- Other methods to cause erections. These include pills, injections, implants, or pumps.
- A medicine called REVATIO. VIAGRA should not be used with REVATIO as REVATIO contains sildenafil, the same medicine found in VIAGRA.

POSSIBLE SIDE EFFECTS OF VIAGRA

Side effects are mostly mild to moderate. They usually go away after a few hours. Some of these are more likely to happen with higher doses.

The most common side effects are:

Headache • Feeling flushed

· Upset stomach

Less common side effects are:

- · Trouble telling blue and green apart or seeing a blue tinge on things
- Eyes being more sensitive to light Blue

Blurred vision

Rarely, a small number of men taking VIAGRA have reported these serious events:

- Having an erection that lasts more than 4 hours. If the erection is not treated right away, long-term loss of potency could occur.
- Sudden decrease or loss of sight in one or both eyes. We do not know if these events are caused by VIAGRA and medicines like it or caused by other factors. They may be caused by conditions like high blood pressure or diabetes. If you have sudden vision changes, stop using VIAGRA and all medicines like it. Call your doctor right away.
- Sudden decrease or loss of hearing. We do not know if these events are caused by VIAGRA and medicines like it or caused by other factors. If you have sudden hearing changes, stop using VIAGRA and all medicines like it. Call your doctor right away.
- Heart attack, stroke, irregular heartbeats, and death. We do not know whether these events are caused by VIAGRA or caused by other factors. Most of these happened in men who already had heart problems.

If you have any of these problems, stop VIAGRA. Call your doctor right away.

HOW TO TAKE VIAGRA

Do

- Take VIAGRA only the way your doctor tells you. VIAGRA comes in 25 mg, 50 mg, and 100 mg tablets. Your doctor will tell you how much to take.
- If you are over 65 or have serious liver or kidney problems, your doctor may start you at the lowest dose (25 mg).
- Take VIAGRA about 1 hour before you want to have sex.
 VIAGRA starts to work in about 30 minutes when you are sexually excited. VIAGRA lasts up to 4 hours.

Don't:

- · Do not take VIAGRA more than once a day.
- Do not take more VIAGRA than your doctor tells you.
 If you think you need more VIAGRA, talk with your doctor.
- Do not start or stop any other medicines before checking with your doctor.

NEED MORE INFORMATION?

- This is only a summary of important information. Ask your doctor or pharmacist for complete product information OR
- Go to www.viagra.com or call (888) 4-VIAGRA (484-2472).

Uninsured? Need help paying for Pfizer medicine? Pfizer has programs that can help. Call 1-866-706-2400 or visit www.PfizerHelpfulAnswers.com.





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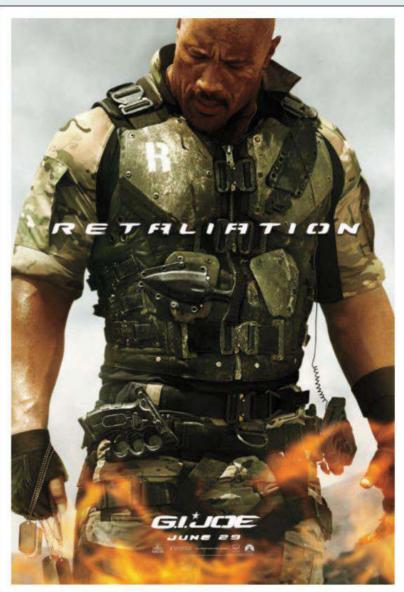
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IN THEATERS JUNE 29 GIJOMOVIE.COM

Home Clinic

BY ROY BERENDSOHN PHOTOGRAPH BY SETH SMOOT

Handle With Care

I have some old farming tools that have been in my family for years, and I want to restore them. Most need wood handles that I can't find for sale anywhere. Please help.



Tip: For the strongest grain orientation, place the oval grain rings on the new handle so they are on the side, not the top or bottom.

It's tremendously satisfying to put a tool back in working order, especially one that connects you with your ancestors.

I've done the job many times, and I always start by contacting the House Handle Company (househandle.com). The 70-yearold family business in Cassville, Mo. (pop. 2185), makes handles of white oak, ash, and hickory for hammers, axes, wheelbarrows, picks, and hoes—as well as for some very obscure tools. I've worked with tools all of my adult life and have written about them for this magazine for 25 years, yet House makes handles for ones I've never heard of.

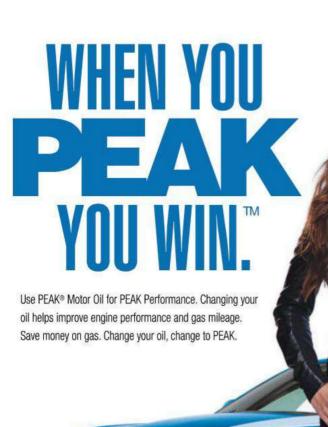
The first step in replacing a handle on an agricultural tool is pretty straightforward—you just knock off the head and the ferrule (the metal sleeve on the handle's end) with a hammer. If the head is secured by rivets, grind off their heads, and drive out the shanks using a pin punch and a ball-peen hammer. Alternatively, you can drill out a rivet: Place a center punch on the head, whack the punch with a hammer, and drill on the center mark. If the head doesn't come off and ride up the drill bit, shear off what remains with a sharp cold chisel.

Now you can connect the toolhead to the new handle. It's important to get the proper grain direction for handles on shovels, forks, hoes, and rakes (see the drawing at left). Next, drive the handle into the tang (the long metal tab) at the end of the head.

To rivet on a new handle, drill through the handle, guided by the old rivet holes. Insert the rivets, place the socket on a firm surface, such as a block of 4 x 4 lumber, and dome the rivet head with a ballpeen hammer.

Finally, clean off any rust on the toolhead using coarse sandpaper











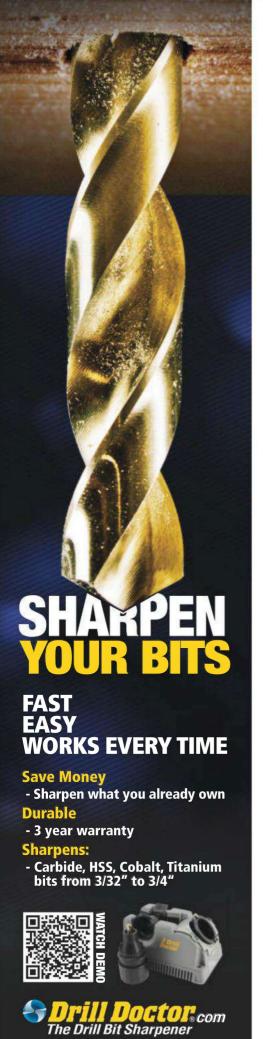
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DIY HOME / HOME CLINIC

and a wire brush. Sharpen any dull cutting surfaces with a 10-inch Home and Garden file (coopertools.com). Shoot a thin film of spray lubricant onto the toolhead, and you're ready to go to work.

Clean Cut

When I'm painting, I never can seem to get a clean line in the corners. I've tried masking tape and bought trim brushes. No matter what I do, it never comes out neat. What's the trick?

You need one of two things to cut a clean line: a steady hand or masking tape. If you use the latter, buy high-quality blue or green crepe painter's tape. Tan masking tape is cheaper, but it's all but impossible to get a crisp line with the stuff.

Using a clean, damp cloth, wipe down the surface where you are going to apply the tape. This removes dust that would prevent the tape from bonding; if the tape doesn't bond, paint will get under it and you'll be left with a messy line when you remove the tape.

Apply the tape to the edge, but take care not to stretch it as you press it into place. Finish by burnishing the tape onto the surface using a metal or plastic putty knife.

Spread the paint and let it dry to the touch before stripping the tape. If you're really concerned about leaving a clean edge, carefully run a utility knife along the paint line to score it before removing the tape. Now gently pull the tape off the surface. If you hear a sharp ripping noise as the tape is coming off the wall, the ceiling, or the trim, you're moving too fast. Pull the tape firmly from the surface and angle it back at 45 degrees so it comes away in a shearing action.

The no-tape option is freehand-painting, or "cutting in," a clean line. Buying a high-quality trim brush is a good start—but be sure that it's the right brush. Most cutting in is done with one that's 2 or 2½ inches wide. A brush that's much wider or narrower is more difficult to control. Also, the brush should be appropriate for the paint you're applying. A natural- or China-bristle brush works well with alkyd (oil) paint but goes limp in water-based paint, making cutting in a clean line impossible. Water-based paints call for a brush with synthetic bristles made of, say, nylon. Once you've got the right paint-brush pairing and you're ready to cut in the line, dip only the bottom inch of the bristles into the paint. Oversaturation with paint makes even the best brush tough to control.

Professional painters can adeptly pull or push a brush and get a razor-sharp line in a corner. Most of us amateurs, though, will probably have better results if we pull the brush toward ourselves, keeping a small bead of paint rolling along the edge of the brush as we move it along the corner.

Floored

I spilled some battery acid on my concrete garage floor, and even though I thoroughly rinsed the area with water, the acid still left some large white spots. How can I restore the floor?

Battery acid is tough stuff, as you've discovered. In this case, it appears to have etched the floor. Given the fact that you've already rinsed the area, you may be able to conceal the blotches by carefully brushing on concrete stain to match the

color of the surrounding surface.

Send your questions to pmhomeclinic@hearst.com or to Home Clinic, Popular Mechanics, 300 W. 57th St., New York, NY 10019-5899. While we cannot answer questions individually, problems of general interest will be discussed in the column.

If this doesn't give a satisfactory result, stain the entire floor. To do this, first clean the concrete with a degreaser like the one from H&C (hcconcrete .com). Next, dampen the floor and sprinkle on the company's etching solution, scrubbing it in with a stiff broom. Finally, rinse the area; when dry, apply a concrete stain. PopMech









Science



BY MADELINE BODIN

FLASH MOB

Fireflies could be slowly flickering out of existence. Serious bug watchers think they've observed a recent decline, but scientists aren't certain-firefly populations go through natural booms and busts. Getting a read on them is difficult, says Don Salvatore, coordinator of the Firefly Watch project at the Museum of Science, Boston. "Fireflies are much more complex than people realize," he says. "It's not like counting birds or flowers or butterflies."

Now, firefly fans across the U.S. can help scientists gather crucial data while spending leisurely evenings in their own backyards. Firefly Watch provides tips for identifying telltale flash patterns; in return, volunteers submit weekly observations, plus details about their local landscape. Such information may help scientists tease out the effects of lawn mowing, pesticides, and light pollution (fireflies' flashes, the insect equivalent of a listing on Match.com, can be drowned out by porch lights and streetlights). Sign up to participate, or help interpret the data collected so far, at mos.org/fireflywatch. PopMech



GUIDE: MEET THE BEETLES

There are about 200 species of fireflies, or lightning bugs, in the U.S. The grubs of all species glow, but only adults east of the Rockies flash. Each species has a distinct flash pattern, which speeds up or slows down according to the temperature. Here are seven of the most common.

- SPECIES: Photinus consimilis [slow pulse] // GLOW: yellow-green // MALE FLASH PATTERN: Two to three ½-second flashes every 15 seconds.
- SPECIES: Photinus consimilis [fast pulse] // GLOW: yellow-green // MALE FLASH PATTERN: Four to nine flashes every 11 seconds.
- SPECIES: Photinus ignitus // GLOW: yellow-green // MALE FLASH PATTERN: A guick 1/2-second flash every 5 seconds.
- SPECIES: Photinus consanguineus // GLOW: yellow-green // MALE FLASH PATTERN: A double 1/4-second flash every 6 seconds.
- SPECIES: Photinus marginellus // GLOW: yellow-green // MALE FLASH PATTERN: A 1/4-second-long flash every 3 seconds.
- SPECIES: Photinus pyralis // GLOW: yellow-green // MALE FLASH PATTERN: A 1/2-second-long flash every 6 seconds.
- SPECIES: Pyractomena angulata // GLOW: amber // MALE FLASH PATTERN: A rapid flicker every 3.5 seconds.



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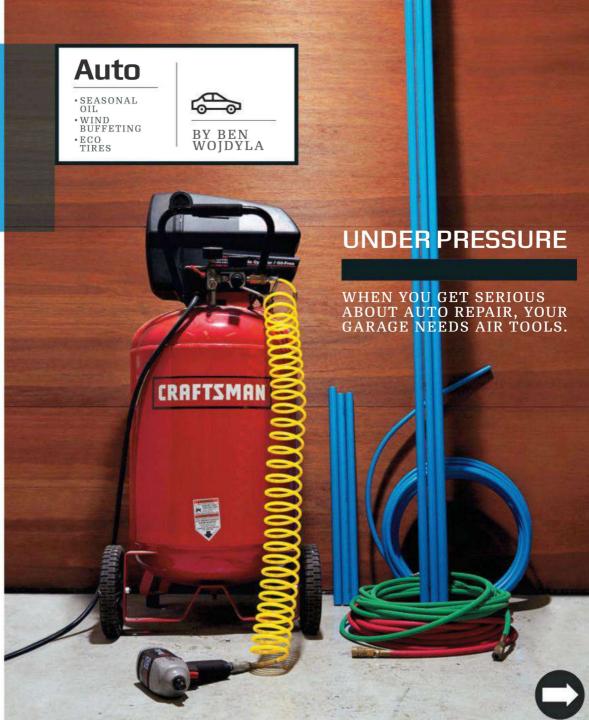
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Vertical compressors save floor space and can plumb into a permanent shop air system. Buy the right size unit, though; nothing's worse than a compressor constantly buzzing away while

you work.

YOU CAN TELL BY THE EXTENT of a car guy's air system when he's gone from hobbyist to automotive mental patient. For grease monkeys the world over, air tools elicit envyand for good reason. Their speed and power make car work dramatically easier and put more projects within reach. With a properly sized shop air system, cutting, grinding, polishing, painting, sanding, inflating, and even cleaning up take less time and sweat. Assembling a system for yourself can be a little daunting because there's no shortage of lingo and fiddly components. We've put together a guide to the basics, along with a roundup of the tools we have in our own garage. Be warned, air tools can spoil you.



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AIR COMPRESSOR

Compressors are sized by SCFM-standard cubic feet per minutethe measure of how much air the machine can deliver when running constantly. An air compressor's SCFM sets the minimum per-

formance of the system hooked up to it, so look to the consumption rate of the tools you use to decide how to size the compressor. There are two types: Single-stage units are smaller and louder, cycle more often, and are less expensive. Two-stage compressors are quieter, cycle less frequently, and deliver lots of continuous pressure. Pressure tank size is another variable. Bigger tanks hold more air, so the compressor won't kick on as often, but small tanks are portable. For more capacity, connect additional tanks by plugging into a quick-disconnect coupling with a rubber hose.



The End of the Line

The price of air tools varies wildly. Spend more on the tools you use the most, but feel free to shop for discounts on everything else.

PIPES, HOSES, AND FITTINGS

Design your system of air lines based on budget, garage size, and how often you use your tools. Flexible %-inch rubber air hose is inexpensive and easy to store for the small shop and occasional use. With a bigger garage, consider permanently installed rigid air lines. Options range from simple iron pipe threaded together and sealed, to a slick system from Rapid-Air. The company's modular wall-mounted high-volume hard-pipe or semirigid in-wall kits are assembled by using just a pipe cutter and reamer; if you want, the two systems can be used together.

With all setups, hoses and tools connect via a quick-disconnect coupling. This standardized fitting is threaded onto a hose or pipe end and positively connects the female end on the tool to the male end on the supply side. Be sure to use thread seal tape or plumber's dope for airtight joints.

40 selle 2300

[1] INFLATOR AND AIR GAUGE

Price range: \$10 to \$40 Fill flat tires and never lose the pressure gauge; these flexible fillers make inflation a snap.

[2] DRILL

Price range: \$40 to \$200 Air drills have the grunt to bore big holes in metal and never overheat or run out of power.

[3] ORBITAL SANDER

Price range: \$30 to \$120 Air sanders offer more power than electric, a smoother action, and don't fatigue your hands as quickly.

[4] RATCHET

Price range: \$30 to \$150

 Manual ratchets do the job, but these are faster and save time on big projects.

[5] CUTOFF WHEEL

Price range: \$20 to \$80 It is the must-have tool for fast and dirty metal cutting.

[6] PAINT SPRAYER Price range: \$60 to \$450

 High-volume, lowpressure paint sprayers deliver great results.

[7] DIE GRINDER

Price range: \$20 to \$120 These are excellent for cleaning off paint, smoothing pitted rusty areas, and grinding down any metal that's asking for it.

[8] HAMMER/CHISEL

Price range: \$60 to \$450 Separate stubborn parts with an air hammer-good ones come with many useful ends.

[9] BLOW OFF

Price range: \$2 to \$10 A valve and nozzle, this tool makes cleaning debris out of hard to reach places a snap; it also makes sweeping a thing of the past.

[10] IMPACT WRENCH

Price range: \$60 to \$450 The iconic air tool, it develops up to 700 lbft of torque, so use it wisely and with a set of high-strength impact sockets.

[11] RECIPROCATING SAW

Price range: \$40 to \$130 Great for clean cuts in metal, plastic, or wood.



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DIY AUTO / TACTICS



or every penny that gas prices go up, Americans spend \$1.25 billion more per year at the pump. No one wants to waste that kind of money. So unless you're hauling the whole ball team, I IT'S TIME TO UNLOAD THE OLD SUBURBAN. And you, Honda Element fella, stop smirking: You're getting only 20 mpgand driving something even less aerodynamic.

> If you're driving something that gets reasonable fuel economy, drive it reasonably. When entering a highway, 2 ACCELERATE TO 60 MPH AT ABOUT DOUBLE YOUR CAR'S TOP 0-T0-60 TIME. AS POPULAR Mechanics proved in a

battery of tests, this puts the car in its more efficient top gear quicker than the smug hypermiler crawling up to speed . . . in the left lane.

[3] COAST—IN GEAR. The same tests showed that rolling in neutral

requires a trickle of gas to keep the engine running but in-gear coasting does notand that if you anticipate traffic lights and [4] DON'T COME TO A **COMPLETE STOP, you** can boost mpg by as much as 50 percent.

A warm engine is more efficient, so string errands together by **DRIVING TO THE FARTHEST DESTINATION** FIRST, which will get the block heated up, then work your way home.

When it's warm out, keep

cool by opening the windows, enjoying the breeze, and [6] **TURNING OFF THE GAS-DRAINING** A/C. At highway speeds, however, our tests showed windows-down driving creates drag. So at 60 mph or faster, roll up the windows and PUT ON THE A/C.

Notice to hoarders: You don't need to lug around a case of oil, a bag of sand, or that box of antique tools you got at the garage sale, right? So [8] EMPTY THE TRUNK-less weight, better mileage. Pickup

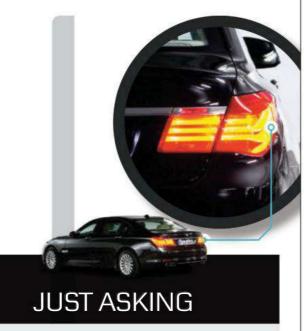
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drivers, [9] REMOVE THE **300-POUND TOOLBOX** FROM THE BED and. while you're at it, [10 **CLOSE THE TAILGATE** to create a drag-reducing air bubble. MythBusters increased the overall range of a full tank by 30 miles using this technique; the show also proved that [11] A **RIGHT-TURN-ONLY ROUTE** increases fuel economy by 3 percent, because idling (at stoplights, for instance) wastes fuel. For that same reason, [12] AVOID TRAFFIC PINCH POINTS. Driving at speed is more fuel efficient than creeping along in low gear. And if you're not regularly carrying a bike or a kayak on that roof rack, reduce drag by SLIDING OFF THE **CROSSBARS** or at least 4] SLIDING THE **CROSSBARS ALL THE** WAY BACK (making a

At the pump [15] AVOID GAS RATED E15; the "E" is for ethanol, which has about 30 percent less energy than gasoline and kills mpg. (Ethanol-free gas is rare today; you'll probably have to settle for E10.) While at the filling station, [1 **INFLATE YOUR TIRES** PROPERLY and check them for uneven wear, which works against you. Stickier, wider performance tires also increase road friction and sap mileage. So [17] STEER **CLEAR OF TIRES MEANT** FOR RACE CARS, and [18] **SWITCH TO ECO-**FOCUSED TIRES, which reduce rolling resistance. Also, [19] GET A TUNEUP; a smooth-running engine is more efficient.

single wing).

Finally, don't overlook the obvious: Nothing saves gas like not driving at all. [20] RIDE YOUR BICYCLE to fetch that quart of milk, especially if the store is just a mile or so away.



WHY AREN'T WE ALL USING ADAPTIVE BRAKE LIGHTS?

In 2002, BMW introduced a controversial redesign of its 7 Series that included one subtle but potentially important innovation adaptive brake lights. These lights, sometimes called emergency stop signals (ESS), illuminate an extra element during hard braking to, hopefully, add urgency to the warning to cars behind you. BMW now includes these lights on its entire product line, and other manufacturers have experimented with various ESS systems (including ones that blink or get brighter). Doesn't this seem like a technology that, if standardized and made universal, could reduce rear-end collisions as well as the overbraking that leads to accordion traffic? The National Highway Traffic Safety Administration has been studying ESS since 2002 but currently has no official plan for the technology—despite research that suggests some ESS methods could be effective. We think it's time to figure out what works and run with it. — GLENN DERENE



WHICH WOULD YOU RATHER HAVE UNDER THE HOOD OF YOUR CAR?





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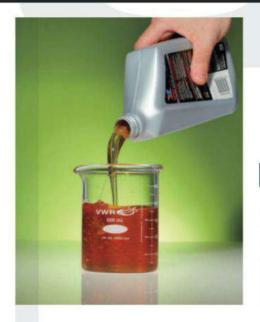
DIY AUTO

Car Clinic

BY BEN WOJDYLA PHOTOGRAPH BY PHILIP FRIEDMAN

Oil for Any Season

Is there really any benefit or downside to using heavier-weight oils in summer months and lighter-weight oils in winter? Some of my older friends swear it's essential to proper maintenance.





Oil is subjected to more misinformation, controversy, out-of-date knowledge, and myth than just about any other aspect of car maintenance. Using the right oil is an essential part of keeping your engine healthy, but what does that mean?

Let's tackle the specifics of your

question first. It used to be that changing oil weight for summer or winter months was part of proper maintenance. Old conventional oil formulations had only one viscosity, and oil would thin out as it was heated. In winter months this caused starting trouble because the oil would turn to molasses and the pumps couldn't lube the engine properly. To combat this, a lightweight oil such as 10-weight was used for cold weather, so it would flow, while heavier 30- or 40-weight oils were best in summer months to prevent the oil from breaking down in the heat. This problem was solved with multiviscosity oil, oil that flows better when cold, then thickens and protects better when it's hot—the best of both worlds. With an oil like a 10W40 (the W stands for winter), the oil flows similar to a 10-weight in freezing temperatures to minus 30 C and protects like a 40-weight at 100 C. With this innovation in oil performance, changing weights for the season is no longer necessary and may be detrimental. Modern oils are very effective across all temperature ranges, and new

engines are designed and tested to work specifically with only the type of oil listed in your owner's manual. Older cars can use modern oils too, just base the first viscosity on your climate, e.g., OW for northern Canada, 10W for Florida, and use the original oil spec for the operating weight. Most older cars work fine with 10W30.

While we're on the topic of oil, it's worth taking a moment to demystify synthetic oil. Synthetics are really just natural oil refined to a much higher degree, with more complex additive packages for improving performance in both everyday and extreme conditions.

Many sports cars come filled with synthetic to offer the best possible protection. Ron Sullivan, Pennzoil's technology manager, broke things down for us. "For most applications, stick with the manufacturer's recommended oil. But if you want to better protect your engine over the long term, especially against extreme abuse like towing or constant stop-and-go traffic, synthetic might be for you." According to Sullivan, a high-quality synthetic flows better at all temperatures, which makes cranking easier in the cold and gets lubrication to critical components faster. It also resists high heat much better, something very critical in the latest turbocharged engines. "When you stop these engines, the oil has to resist being baked by the heat in the turbo's oil bearing, Sullivan says, "And synthetics are better at that." These are bold claims and may be worth considering when choosing oil, but we can't remember the last time an engine failed on conventional oil, so going synthetic when you don't have to may be a waste of money. If you abuse your engine, consider synthetics; otherwise follow the manufacturer's suggestion.

Bad Vibrations

I have a problem when opening a window in my SUV while driving. There's a boom, boom sound which affects everyone in the car and it's worse if it's the driver's window. What can be done to eliminate this problem?

What you're experiencing is called buffeting and it's not unique to your SUV. To boil some very complicated physics down as simply as possible, when you open a window you're

piercing what's known in aerodynamics as a boundary layer. The air racing past your car is at a lower pressure than the air inside the cabin, so opening a window means the inside air wants to get out; however, the air rushing by outside gets snagged on the edges of the open window and tries to get inside. The cabin air resists this intrusion while the pressure tries to equalize and the two layers of air "bounce" off each other. This turbulence in the boundary layer causes a rumbling sound that can

Don't Be an Idint



OPEN A HOT RADIATOR CAP

Engines operate at high temperatures, which means their cooling systems must work within this range as well. Only problem is, coolant can boil in that heat, which makes for inefficient thermal exchange. So just as a pressure cooker raises water's boiling point, the cooling circuit is pressurized to do the same. Assuming your engine is working properly, the coolant is under 10 to 15 psi of pressure when hot. Opening the cap to atmospheric pressure causes rapid depressurization of the hot coolant, and that liquid converts to dangerous steam. Cars with overflow tanks keep pressure sequestered with a spring-loaded valve, but it's better to be safe, and let the engine cool before opening the system for service. When in doubt, place a damp towel between your hand and the cap.



DIY AUTO / CAR CLINIC

be painful to the ears. The effect of buffeting varies based on the cabin shape and aerodynamics of your vehicle, as well as the speed you're traveling. There's an easy fix, though—give the air inside somewhere else to go. Rather than open just one window, crack open a second or the sunroof so the pressure will be relieved. I've found the opposite-corner window works best.

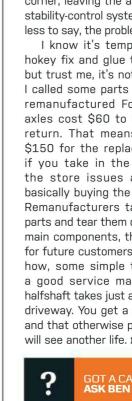
Put a Ring on It

Recently a tone ring on my 2007 Ford Escape cracked and fell off. The dealer said replacing the entire front halfshaft was the only option. What a waste of a perfectly good shaft! Can I weld the ring and, if so, what can be used to reattach it to the shaft-epoxy?

Tone rings are central to the operation of traction-control systems. For the Escape, they're on the end of the halfshaft that connects the transmission to the wheels, riding on the constant-velocity-joint housing. A tone ring looks like a gear and fits onto or near the hub of each wheel of a car. A sensor sits near the ring and detects the presence or absence of one of those gear teeth. By calculating how fast the teeth are moving, the

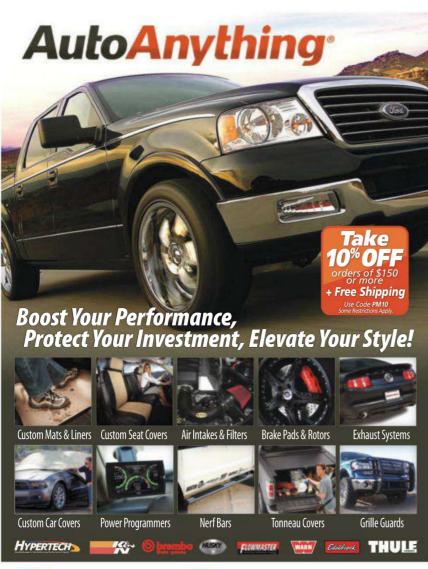
car's computer knows how fast each wheel is turning. After comparing the wheel speeds with what it expects to see, the computer decides if any wheels are slipping under acceleration or braking and makes corrections with the brakes and/or the engine output. Because the ring cracked and fell off, the car can't tell what's going on at that corner, leaving the antilock brakes and stability-control systems hobbled. Needless to say, the problem should be fixed.

I know it's tempting to try some hokey fix and glue the ring on again, but trust me, it's not worth the effort. I called some parts stores and found remanufactured Ford Escape front axles cost \$60 to \$70 after a core return. That means you pay about \$150 for the replacement part, but if you take in the old busted part the store issues a partial refund, basically buying the old one from you. Remanufacturers take the damaged parts and tear them down, clean up the main components, then they're rebuilt for future customers. With basic knowhow, some simple tools, and maybe a good service manual, changing a halfshaft takes just a few hours in your driveway. You get a good-as-new part, and that otherwise perfectly good axle will see another life. PopMech



GOT A CAR PROBLEM? **ASK BEN ABOUT IT.**

Send your questions to pmautoclinic@hearst.com or over Twitter at twitter.com/PopMechAuto or to Car Clinic, Popular Mechanics, 300 W. 57th St., New York, NY 10019-5899. While we can't answer questions individually, problems of general interest will be discussed in the column.







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PEELING OUT

YOKOHAMA'S NEW AVID ASCEND TIRE USES OIL DERIVED FROM ORANGE PEELS TO ENHANCE TREAD LIFE, GRIP, AND FUEL ECONOMY. BY JAMES TATE

Manufacturing tires has always been a compromise between traction, tread life, and rolling resistance. According to Yokohama engineers, you had to "pick one, blend two, or average three." But those same engineers claim that by replacing some of the petroleum typically used in tires with a bit of oil derived from orange peels, they can mitigate the typical compromises. The result is a low-rollingresistance tire that can go for more than 50,000 miles yet still effectively grip the road. The company has been very cagey about the details and won't say how much orange oil it uses per tire. As one engineer cryptically put it, the orange oil is "a percentage of a percentage of a percentage" of the tire. In other words, you won't smell

oranges when you do burnouts in your Nissan Altima. But the Avid Ascend, the new orange oil tire that's available in 45 sizes, includes remarkable treadlife warranties from 65,000 to 85,000 miles. Plus, the company claims a 20 percent reduction in rolling resistance compared with a typical all-season tire. That will save some fuel but probably not enough that you'd notice.

We sampled the tires and found them to be quiet and supple, not at all like the usual stone-hard rolling-resistance tires. We didn't notice any susceptibility to tracking in road ruts, and in the corners there was adequate grip. Our observations are hardly scientific, but we were sufficiently impressed that we'd consider buying these when it's time for new tires. They're slightly more expensive, but with such long tread lives, you should, in the end, come out ahead.

PM ON YOUTUBE The Car and Driver channel will host our own Saturday Mechanic series with PM's associate auto editor Ben Wojdyla. For a chance to appear on the show, submit your car-related questions to popularmechanics.com/cdchannel.

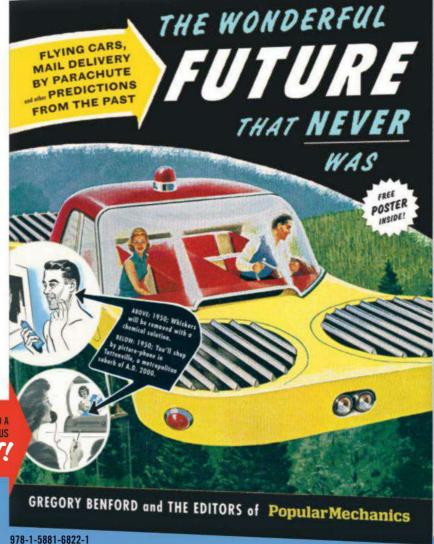




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3. CORRECTION / Use your bottom hand to pry the blade away from the boat. Just a few inches of ruddering will tame a bit of bow drift, but more correction will require a hard push. [You're doing it right if your tricep muscle protests.]

4. RETURN / Need a bit more correction? Drag the blade tip through the water for a few inches as you bring the paddle forward.

GOING IT ALONE

PADDLING A **CANOE SOLO** ISN'T HARD: **JUST KNEEL** AND HEEL-THEN EMPLOY A ROCK-SOLID STROKE.



addling on your own is like having a backstage pass to every overlooked lake cove and river slough. Take your canoe where you want, as fast as you want, without the hassle of coordinating strokes—and schedules—with a partner. Burt Kornegay, who owns Slickrock Expeditions, has guided more than 400 trips, but he still likes going out on his own. "There's a sense of freedom," he says. "You can go at it hard, or snooze all afternoon. And solo paddlers see so much more wildlife because they're quieter." Here's how to transition from two motors to one. PopMech

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Tech



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FIX IT IN POST

FIVE SOFTWARE STRATEGIES THAT TURN HOME VIDEOS INTO HOME MOVIES.

The past 30 years of video technology have democratized moviemaking—maybe too much. Anyone can now shoot high-definition video on a smartphone and instantly upload it to YouTube for the entire world to see. That type of uncut cinema verité style makes for good cat-playing-piano clips (if there is such a thing), but the videos that are truly important to you deserve more polish.

1

The best way to get great results in the editing bay is to shoot quality footage in the first place, with a strong sense of the tale you want your video to tell. But it's amazing how a little bit of work in a basic video-editing program can turn some less than perfect clips into a dramatic exercise in visual storytelling.

Resist the impulse toward special effects and other visual tricks—if you don't know how to organize, arrange, and splice your clips into a harmonious narrative, then all that stuff is just decoration on an unbaked cake. Following these simple guidelines will do a lot more for your video.

Most consumer-grade video-editing programs are nonlinear, which means they allow you to grab and manipulate your clips without destroying the original material. Software such as Windows Live Movie Maker and Apple's iMovie and shareware such as

AVS Video Editor use a storyboard that lets you lay out your clips and rearrange them however you like. Most professional moviemakers would start with a script, then storyboard before they shoot anything. But for clips you've already taken, you're going to have to do that process in reverse. Take the clips you want to use and drag them to the board, then rearrange them until you see a story emerge. Don't worry about clips blending together at this point, just look for a rough sense of narrative progress. Consider the mood and pacing of the footage. Is it sports video with lots of movement and action? Are there lots of closeups and dialogue? Has your subject been shot from multiple angles? The longer you want your movie to be, the more variety you should be looking for. If it seems as if something's missing, make notes about additional footage, or B-roll, you can film to fill in the blanks (iMovie has dummy clips called Animatics that you can use as placeholders).

WEEKEND

2

TRIM THE FAT

It's good to overshoot when it comes to video. But the more footage you have, the more ruthlessly you have to cut in postproduction. The process of editing is all about being

selective and stitching together your best material in a way that tells a story efficiently. In each clip, look for the crux

of the action and drop anything that's not pivotal. (Most programs let you trim with a simple select and delete.) As a general rule, try keeping clips under 10 seconds—short shots will give your movie a lot more energy than longer ones. That said, don't cut your clips so short that they become confusing.



<u>CLEAN IT UP</u>

It's best to plan your lighting, composition, and camera technique before you shoot, but in case that didn't happen, there's still plenty you can do with software. The capa-

bilities vary from program to program. Windows Live Movie Maker is the least sophisticated, but if you're willing to tinker with third-party filters, you can use the free, linear VirtualDub program to do some basic corrections, then import the clips into WLMM for editing. More sophisticated video suites such as iMovie and AVS offer cropping, color correction, and stabilization, which can compensate for sloppy camerawork. Tinkering with the image can have a downside, however—digital cropping and stabilization can lower resolution. But used judiciously, these tools can help smooth out variation from clip to clip, or turn a bland shot of someone talking into a dramatic closeup.



BLEND IT TOGETHER

Frequent cuts and angle shifts make a movie more dynamic, but done wrong, these techniques can be jarring. Knowing how to

gracefully move from one shot to another is an art form. Most video editors offer lots of fancy sweeps, mosaic dissolves, and other spinning, flipping novelty transitions, but if you trust your material, keep it simple. Transitions are usually found under a menu or palette (some software labels them effects). Don't use too many kinds of transitions—stick to quick cuts for back-and-forth dialogue, crossfades for blending clips together, and fades to either black or white ing dia for complete scene changes.



SMUUTH OUT THE SOUNDTRACK

Unfortunately, the built-in mics on camcorders and smart-phones are uniformly awful for recording dialogue. If you were unfortunate enough to capture Bigfoot's first recorded growl in a windy patch of for-

est, both AVS and iMovie offer tools to remove background noise. But remember, software can't perform miracles, and while it's advisable to tinker with the audio settings to get the best results, too much noodling will cause muffled distortion.

Keep in mind that your audio doesn't always have to be tied to your video. If you've got footage of your daughter telling a hilarious story about the family dog chasing its tail, but it's just a still shot of her talking, split the audio track from the video and splice in a shot of the dog spinning around while she tells the story, then cut back to her giggling hysterically at the end—it makes for a far more interesting effect.

Finally, if your recorded audio is garbage or just irrelevant to the action, drop in some music for a mood-setting soundtrack. Editing together wistful memories of your kid growing up? Dial up the sentiment with some Jack Johnson. Trying to make your hockey team's highlights even more awesome? Lay down a track of AC/DC and match the visual cuts to the rhythm changes. But don't invite the wrath of music industry lawyers—if you're posting to the Web, search for royalty-free music on websites such as freeplaymusic.com.



JOEL NEGRON, film editor on Sleepy Hollow, Transformers: Dark of the Moon and 21 Jump Street

... on getting organized

"Go through your video and make a select reel. It doesn't have to make sense, just get your best footage for each section of the story. Some people make multiple select reels for closeups, wide shots, medium shots, or all shots of each actor."

... on adding drama

"When editing, I use music from other movies. You can have a shot of a guy just sitting on a bench, and there's nothing happening, but if the music is telling you to feel sad, then you're going to feel sad, and if the music communicates tension, then you're going to feel tension.

... on filling in the blanks

"If you're editing footage of, say, a football game, and the cameraman filmed a touchdown pass, but missed the ball in the air, then the easiest thing to do is cut to a shot of the crowd, then cut back to the guy running the ball."



OLD SCHOOL TEXT MESSAGING

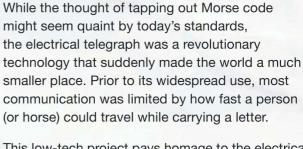
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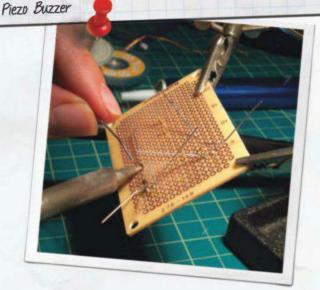
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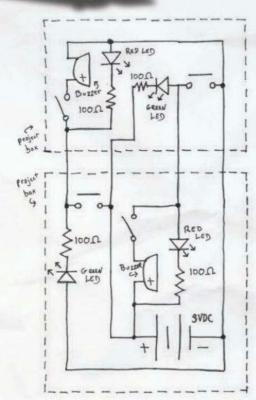


This low-tech project pays homage to the electrical telegraph, and it can be built almost entirely out of basic electrical components available at RadioShack. It uses a fairly simple circuit to send coded "dots" and "dashes" back and forth between two devices that are connected by a length of wire. When you push the transmit button on one of the devices, an LED will blink and a buzzer will sound on the other device. For silent communication, there is a mute switch that turns off the buzzer. (The LED still blinks.)

Each device is built into a project box, and the circuits are slightly different in the two boxes. The battery pack, which powers the entire circuit, is installed in one side. Following the diagram shown here, carefully solder each component onto the circuit board. In the diagram, the dashedline boxes represent each project box, and the four solid lines between the two dashed-line boxes represent the four-conductor wire running between the project boxes.



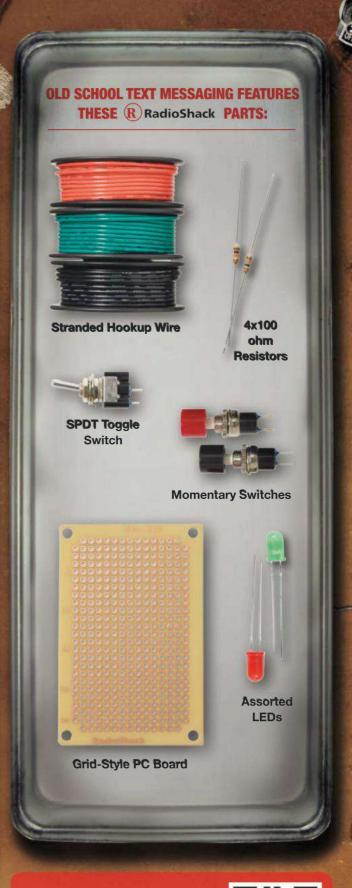
Always wear safety glasses. Avoid breathing fumes and always work in a well-ventilated area. Wash hands thoroughly after use. Follow all safety instructions on solder and soldering equipment packaging. California residents: WARNING: Soldering products contain, or when used for soldering and similar applications produce, chemicals known to the state of California to cause cancer and birth defects (or other reproductive harm).





While your Morse code skills might be a bit rusty, with some practice you'll be sending simple coded messages back and forth in no time. And in this age of amazing technology, it's fun to be able to build your own electronic communication device from scratch!

By Ken Murphy



To see "how-to" video footage for this project and explore other great creations, visit RadioShack.com/DIY.



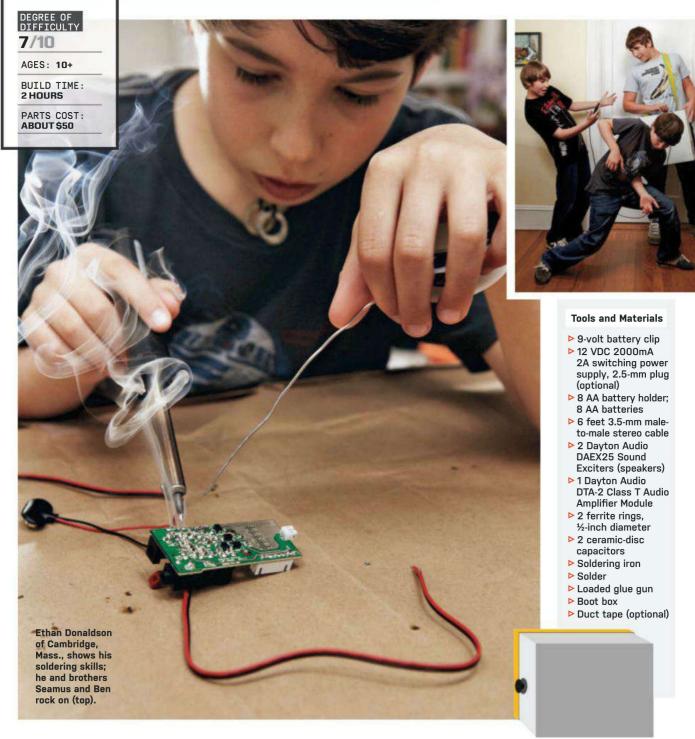


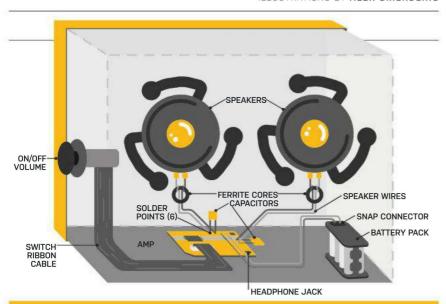
DIY TECH

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HOW TO BUILD IT

Wire the amplifier

- Place the amplifier on a work surface, flat side down; position the amp so that the row of four small holes is on the top edge.
- Strip ¼ inch of the ends of the two battery-clip wires; slip the tips of the wires through two of the four holes closer to the amp's right corner, with the black wire in the outermost hole. Bend and then solder the tips to the flat side of the amp.
- Pair two sets of the red-and-black wires included with the speakers; cut into 15-inch lengths. Strip ¼ inch of each wire tip, then loop each pair once around the rim of a ferrite donut.
- 4. Wrap a tip of one red and one

black wire around the legs of a capacitor. Slip one leg through each of the holes next to those where the battery-clip wires are soldered. The wire colors must alternate: black, red, black, red. Solder the capacitor legs and wires to the amp. (This pair of wires feeds one of the speakers.)

5. Locate the two holes, about ½ inch from the right side of the amp. Repeat Step 4, slipping the tip of a length of black wire through the hole marked with a minus (negative) sign, and a red wire tip through the other hole marked with a plus (positive) sign. Solder in place. (This pair of wires feeds the other speaker.)

Attach the components inside the box

- 6. Apply glue to the flat side of the amp assembly, and stick it to the inside of one of the two larger faces of the boot box. Position the amp so that the switchribbon cable reaches the point on the side of the box where you will install the volume-control knob (step 9).
- 7. Using the self-adhesive tape on each exciter (speaker), affix them to the same face of the box as the amp. Clip the speakers to the two sets of wires attached to the capacitors.
- Glue the battery pack near a lower corner inside the box. Attach the battery pack to the

- amp using the clip.
- 9. Remove the knob from the volume control (this is also the on/off switch). Poke a hole through a side of the box large enough to fit the stem of the volume control. Place the stem through the hole, reattach the knob, and glue the assembly to the inside of the box.
- Plug one end of the switch ribbon into the amp and the other end into the volume-control unit. Glue down the ribbon.
- Plug the ends of the speaker cable into the amp and the device that holds your music library.

Attach your device

12. Turn on your device with the volume on high, choose your favorite playlist, and press play. Close the box—and rock on!

Optional steps

Add a handle made of duct tape; punch a hole in the box through which you can feed a switching power supply wire to the amp.

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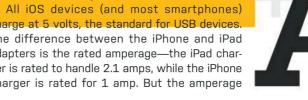
Power Sharing

I've got both an iPad and an iPhone that share the same connector, but their power adapters have different wattage ratings. I travel a lot and would prefer not to take multiple adapters along. Can I use the higher-wattage adapter on both devices?

> Let's start with the official answer: Apple is totally cool with it—the company says so right on the product page for the 10-watt iPad USB power adapter. In fact, Apple lists compatibility with 23 iOS devices dating back to the first-generation iPod Nano. Also, we've tested it—nothing blows up, and the iPad adapter seems to charge the iPhone a bit faster than the stock iPhone charger. So you definitely can charge your iPhone with

the iPad charger. The more interesting question, however, is should you.

charge at 5 volts, the standard for USB devices. The difference between the iPhone and iPad adapters is the rated amperage—the iPad charger is rated to handle 2.1 amps, while the iPhone charger is rated for 1 amp. But the amperage



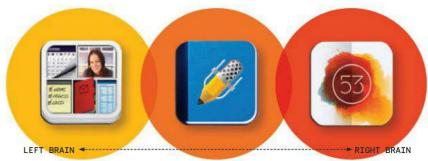






rating is only a measure of the adapter's maximum capability—the actual amperage is determined by the load (i.e., the iPad or iPhone). According to Steve Sandler, founder and chief technical officer of AEi Systems, an electronics analysis company, modern batterypowered electronics have a lot of complexity between the charger and the battery, including batterycharging circuits within the device and battery-protection circuits in the lithium-ion battery itself. These circuits are designed to manage the flow of electricity to the battery, and if the circuits inside the iPhone were designed to tolerate 1 amp, but are routinely exposed to 2 amps, that could stress the system over time. "Even though you may not instantaneously say, 'Wow, I just destroyed my battery!' you may limit its life over the long term," Sandler says, "but you wouldn't know for a year or more." Our advice: Since Apple claims compatibility between the iPad charger and iPhone, pay for the extended two-year warranty for the iPhone to ride out your cell contract, and charge it however you like. If your battery degrades severely after the first year make Apple give you a new one.

THREE APPS TO ORGANIZE YOUR THOUGHTS



BENTO (\$10) Like its namesake, this app is all about compartmentalization. Projects, calendars, car maintenance schedules. recipes, and more can be put into templated libraries for maximum organization. Largely text-based, it functions like a personal card catalog of things you need to get done. It's also a great way to handle inventory and expenses for a small business if you use it with the OSX desktop app (which costs an extra \$50). Bento is expensive for an iPad app, but it's still far cheaper than similar apps such as Things (\$20).

NOTABILITY (\$1) There are plenty of notetaking apps, but Notability is, er, notable for its free-form flexibility. It lets you draw or write on your iPad's screen with a virtual pen in multiple colors (many people choose to use a capacitive stylus for even greater precision). Notability also lets you import photos, diagrams, or Web pages into your virtual notepad and mark them up. Notes can then be exported as PDFs directly to a Dropbox account and automatically synced to multiple computers or shared with friends or co-workers.

PAPER BY 53 (Free, but tools cost \$8) Born from the ashes of Microsoft's scrapped Courier tablet project, Paper is an example of how restraint can increase the usefulness of an app. Paper's virtual brush-and-pen kit has only six tools and a ninecolor palette, and there's no way to drop in photos or zoom in on work. Yet for those who express themselves best visually, Paper can turn a quick sketch into a sophisticated piece of art. Plus. its undo function lets you dial backward in time. This program and a stylus will make an artist out of almost anvone.

Wrists of Fury

I work on a desktop with a mouse and my wrists are killing me. I'm thinking of changing to a laptop. Which is ergonomically better for your wrists, a trackpad or a mouse?

Regardless of whether you're using a mouse or a trackpad, the first thing to consider when alleviating wrist pain is proper ergonomics. In fact, research has shown that products such as padded rests can actually increase the pressure on your wrist. So as motherly as it may sound, correct posture and how you hold your wrist when gripping a mouse or hovering over a trackpad is essential. Make sure your mouse or trackpad is at a comfortable distance (i.e., you're not straining to reach your computer or scrunched in too tight), and keep your wrist straight and off the desk, avoiding jerky motions by using your elbow as the pivot point. With ergonomics out of the way, back to your original question: mouse or trackpad?

Because they allow for more freedom of movement, trackpads are probably the better bet for reducing wrist pain. But Dr. David Rempel, director of the ergonomics training program at the University of California, Berkeley, admits that there hasn't been a definitive study on this topic. His own research on touchscreens, however, suggests touch interfaces are more ergonomically kind, but they're also associated with slower input speeds. Depending on the nature of your work this might not matter. Even if it does slow you down, Rempel suggests forcing yourself to switch occasionally to alleviate repetitive-stress injuries. (The stresses become less repetitive.) You might also try changing mouse/trackpad hands. It will be awkward at first, but spreading the load between hands also reduces pain—and the switch-up will be a good workout for your brain. PopMech



Send your questions to pmdigitalclinic@hearst.com. While we can't answer questions individually, problems of general interest will be discussed in the column.

LOOKING DOWNRANGE

CONTINUED FROM PAGE 83

truck then moves. It's a variation on an infantry advance, played out with heavy vehicles, remote-control cameras, and frightened field mice.

Today, the machine guns are left behind as the team practices communication and coordination. A-Team members must be quick learners. The Army's M-ATV official training schedule lasts about two weeks; Alpha's team has only five days. "You'll never catch anyone in special operations saying something can't be done," Alpha says. The next day, they'll mount guns on the CROWS, put a trunk monkey on an M249 squad automatic weapon, and drill on a range with live ammunition.

After the exercise ends, the team clusters on a hilltop to discuss how the bounding overwatch can be improved. In a spec ops A-Team, everyone is free to chime in with critiques. This collaborative atmosphere is a marked difference between conventional and special operations forces. All ranks call each other by first names (Alpha is still "sir"). Leaders ask questions and solicit advice more than they bark orders; mission planning is done with everyone's involvement. The operators contribute critiques but rarely gripe. "It's a team, and so you need to get a consensus," Alpha says. "These are not guys who want to say 'yes, sir, no, sir' blindly."

It's easy to trust the level of dedication of SOF operators-they need direction, not micromanagement. "I was in the [conventional] Army before this, and I worked with a lot of people who didn't want to be there. Everyone here really wants to be here," another junior Echo on the team says. "You feel much better about an operation when you're part of the planning."

SOCOM says the typical operator is 29 years old (officers average 34) and married with at least two kids. This team's stats are skewed by the senior Echo, who has nine children. Team members come from all over the country and represent a dizzying polyethnic mix: Korean American, black Asian, Malay Indonesian. Any demographic differences fade before the bond of their profession. "After this training I'll put the guys on a four-day weekend," Alpha says. "It won't matter. They're just going to hang out more. This job consumes their lives."

The afternoon is spent towing an M-ATV. Alpha runs the drill as if the team is under attack and needs to get the crippled M-ATV out of the range of enemy weapons (the "kill zone.") Some operators pop out from the rescue vehicle to provide cover with M4 and SCAR-H rifles, while the rest buckle a forearmthick rope to the "stalled" M-ATV. The engine roars, the two vehicles jolt violently, and the lead M-ATV drags the other to safety.

The drill is a success, but the team runs it again anyway. This time the rope snaps; it may have snagged on metal or simply been used once too often. The severed line whips a bloom of brown dust off the massive spare tire mounted on the M-ATV's rack. "It's not a full day in special operations until we break something," Alpha says. This time the Pentagon got off cheap.

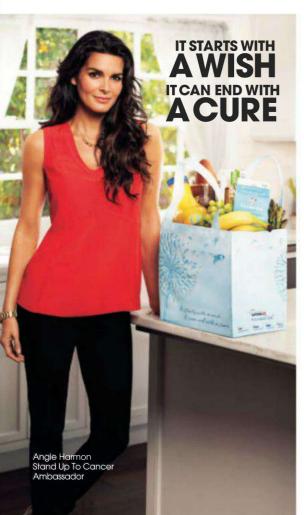
GUERRILLA VS GUERRILLA

In Afghanistan, Alpha's team will try to create a local force, backed by a credible government, to keep the insurgent wolves at bay. "We are trained to be guerrillas," Alpha says. "Who'd be better at being counter-guerrillas?"

The Pentagon calls them force multipliers for a reason. "Every guy is expected to lead one company-size element, up to 100 guys," Alpha says. "I'm supposed to lead a battalion, or 600 guys."

Every member of a 12-man special operations team has made himself into an avatar of the most idealized version of the nation he serves. The pressure is always on to appear perfect in front of conventional and foreign forces. "We always want to build the aura that we are masters of chaos and jacks-of-alltrades," Alpha says. "Expectations are really high. We have to give them what they expect."

The team's Charlie (construction and demolitions specialist) points out that there's a lot of diplomacy involved in being an elite warrior: "I could be talking to a [foreign army] colonel in the morning, the provincial governor in the afternoon." He has no illusions about how hard it will be to operate in Afghanistan. "I could be heading out to the market to



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pick up lumber to build a school. Then we're told about an IED [improvised explosive device] and have to go handle it," he says. "Then back to the market, buy the supplies, distribute them, and do the accounting when I get back."

The attacks on Afghans who support the government in Kabul-and the United States-will only grow as 2014 approaches. The police units that spec ops teams train have been the targets of infiltration and murder. "We talk to guys who are over there now," Alpha says. "We're expecting a hard fight."

GOING HOT

With guns mounted on the roof and rear cargo area, the M-ATV is transformed from a truck to a war machine. The A-Team has mounted a .50-caliber machine gun on top of the M-ATV; an Echo seated inside the armored vehicle uses a joystick and the CROWS' video screen to slew the weapon and pick targets.

"Okay, captain, are we going hot?" the gunner asks.

"Yep," Alpha responds from the shotgun side of the front seat.

"Cool."

Alpha scans outside the ballistic glass for cutout wooden targets scattered around the firing range. "Black truck silhouette at two o'clock." The landscape behind the reticule on the CROWS screen swings as the gun mounted on top swivels. "Contact," says the Echo, spotting the target. He presses a red button, bouncing a laser off the target to gauge its distance.

It's taking too long. "Engage targets," Alpha prompts. The .50-cal. thumps and those inside can hear the shattered crystalline sound of 4-inch casings cascading across the hull. Red tracers bounce off rocks and carom 30 feet into the air at crazy angles. The targets are instrumented to fall after a designated number of rounds hit; one by one they drop, ventilated by heavy bullets. "Alpha, this is Zulu," the senior nonenlisted man radios from the other truck, an older RG-33 that has an M240 mounted in its CROWS. "We are moving into position." The RG-33 rolls as the M-ATV provides covering fire. When both trucks are in position, they concentrate their attack on the same targets. The vehicles rattle through hundreds of .50-caliber and 7.62-mm rounds.

The exercise ends and the huddle reconvenes. Details are discussed: advantages of the CROWS' camera stabilization, the importance of the gunner's use of the laser rangefinder to communicate distance to the front-seat spotters, and the best way for the leapfrogging vehicles to communicate.

The sun bows to the horizon, outlining silhouettes of distant, sharp mountain peaks. The team runs the exercise again-and again. "We drill on the basics until we're perfect," Alpha says. "That's what makes us special."

By the time they return from the day's last gun run, darkness has fallen.

Rock-hard pears, a slab of pale turkey, and sickly, over-sweetened yams await them for a dusty dinner at the range. They eat by the light of the M-ATV headlights. After the grim meal, the weapons are dismounted, extra ammo stowed, and worn, wooden DANGER LIVE FIRE warning signs collected from the range. "This is the tempo," Alpha says.

Then it's back to the barracks to clean the weapons. The team won't finish until 1 am. Alpha and Zulu will then finish reports and finalize the training schedule for the next day. By the time they lie down in their barracks, PT is only a few hours away. PopMech

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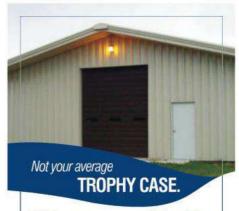
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A BRIEF HISTORY OF ...

Fireworks

Once just simple incendiary devices, fireworks have become a spectacular staple of celebratory displays. Here's how humanity has lit up the sky through the ages. BY AMANDA GREEN

200 B.C.

It starts with a big bang. Bamboo thrown on a fire in China explodes as air expands inside the reeds, and rudimentary firecrackers are born. Locals decide they should be used to scare away evil spirits.

A.D. 600 TO 900

Things get pyrotechnical when a Chinese alchemist combines sulfur, saltpeter, and charcoal and sets it on fire. The more oxygenrich the saltpeter, the bigger the explosion. Soon the Chinese pack powder, rocks, and metal into containers to make weapons.

O 1295

Marco Polo brings fireworks to Europe from the Orient. (Also: porcelain, iewels, spices, and other less exciting items that don't go boom.)



1400 TO 1500

The Renaissance begets unparalleled advances in art, literature—and fireworks. The Italians launch projectiles and burn powdered metals and charcoal slowly in open tubes to create sparklers. Controlled fires become de rigueur at coronations. Commoners miss out on the fun.

O 1635

John Bate publishes the four-part book series The Mysteries of Nature and Art. In part two, he outlines how to create flying dragons, along with other fiery spectacles. Among those the book inspires: a young Sir Isaac Newton.



Powder to the people! In England, fireworks shows become public spectacles for everyone to enjoy. Colonists bring them to the Americas. where they set them off on Independence Day 1777 and think, we should do this again next year.

O 1830s

Italian pyrotechnicians add color to fireworks with chlorinated powder and metallic salts (strontium = red, barium = green, copper = blue, sodium = yellow). Using potassium chlorate as an oxidizer makes the hues brighter.

1966

Cherry bombs, first used as weapons during the Civil War, are banned in the U.S. But until his death in 1978, Keith Moon, drummer of the Who, blows off steam-and blows up hotel toilets-with illegal cherry bombs.

The U.S. Consumer **Product Safety Commis**sion requires fuses on consumer fireworks to burn for at least 3 seconds but no more than 9. Safety warnings on fireworks labels become protocol.

1999

Disney World launches fireworks with compressed air instead of gunpowder at Epcot's pyrotechnic spectacular IllumiNations: Reflections of Earth. Disney is the largest U.S. consumer of fireworks, making its theme parks the "happiest places on earth" for American pyromaniacs.



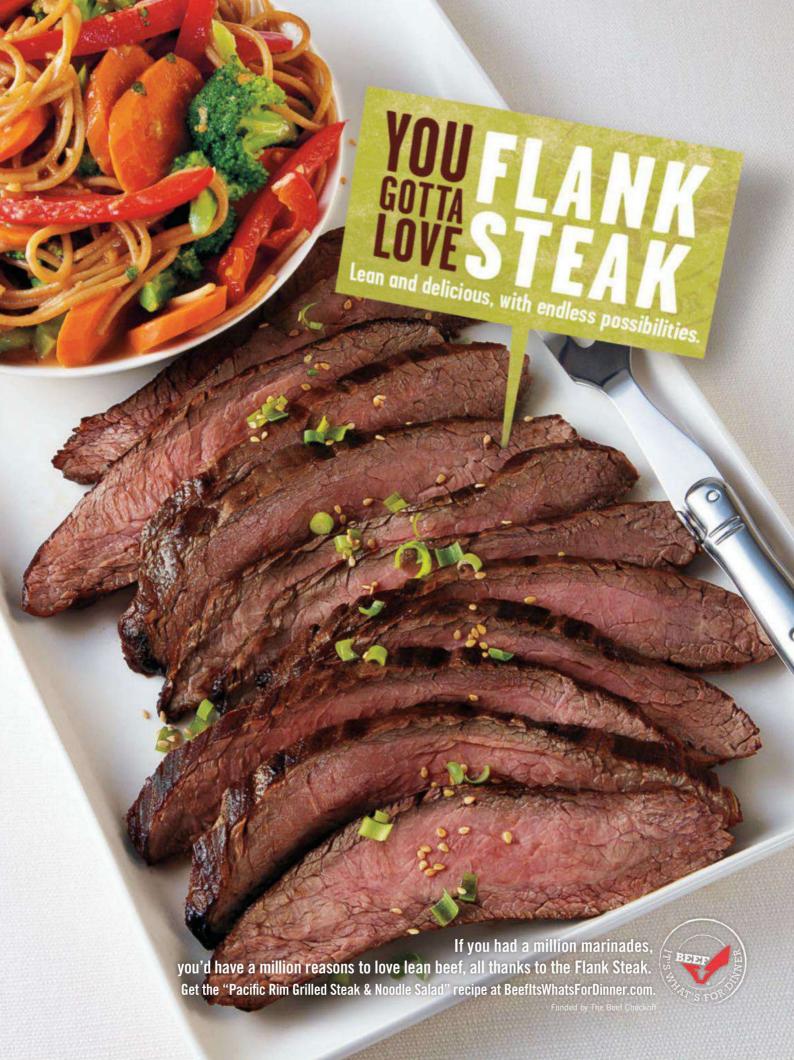
The Chinese Olympic Committee admits that CGI was used to enhance fireworks footprints that appeared to walk across the sky for TV audiences and fans watching the Beijing stadium's Jumbotron. The New York-based Grucci family, who created the actual display, is not amused.





Pop singer Katy Perry releases the empowering single "Firework," reportedly inspired by a passage from Jack Kerouac's 1957 novel On the Road.





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